1.0 HUMAN HEALTH ENDPOINTS

Results of studies on naphthas high in paraffinic, olefinic naphthenic and aromatic constituents are summarized in this section. Although some studies were performed by the oral and dermal routes of exposure, inhalation has been identified as the route most relevant to human exposure for purposes of hazard and risk assessment. The mammalian toxicology and environmental profiles on these blending streams are supported by comparable test results on gasoline from studies in the US and Europe. In addition, a testing program currently in progress mandated by the Clean Air Act 211(b) statute on an EPA designated "industry average" gasoline vapor condensate provides even more current data on mammalian toxicity of gasoline.

1.1 Human Health Effects

1.1.1 Acute Toxicity

Light alkylate naphtha (API 83-19; CAS #64741-66-8; approx 100% paraffinic) is not acutely toxic by the oral (rat > 7000mg/kg), dermal; (rabbit > 2000mg/kg) and inhalation (rat > 5mg/l, 4 hr exposure) routes and is non-irritating to the rabbit eye 24 hrs after exposure. It is a moderate skin irritant in rabbits but is not a skin sensitizer in guinea pigs. (API, 1986a, 1987a)

Light catalytic cracked naphtha (API 83-20; CAS #64741-55-5, approx. 46% olefinic) is not acutely toxic by the oral (rat > 5000mg/kg), dermal (rabbit > 3000mg/kg) and inhalation (rat > 5.3mg/l, 4 hr exposure) routes and is not irritating to the rabbit eye 24 hrs after exposure. It is a moderate skin irritant in rabbits but is not a skin sensitizer in guinea pigs. (API, 1986b, 1987b)

Sweetened naphtha (API 81-08, CAS #64741-87-3, approx. 21% naphthenics) is a light straight run naphtha in which a sweetening process has converted mercaptans and removed acidic impurities. It is not acutely toxic by the oral (rat > 5000mg/kg), dermal (rabbit > 2000mg/kg) and inhalation (rat > 5.2mg/l, 4 hr exposure) routes and is not irritating to the rabbit eye 24 hrs after exposure and only a mild skin irritant in rabbits. (API, 1986c, 1987c)

Full range catalytic reformed naphtha (API 83-05, CAS #68955-35-1, approx. 63% aromatics) is not acutely toxic by the oral (rat = 3500-9800mg/kg), dermal (rabbit > 2000mg/kg) and inhalation (rat > 5.22mg/l, 4 hr exposure) routes. Eye irritation observed within 1 hour of instillation gradually resolved over 7 days and was not apparent at 14 days. It is a moderate skin irritant in rabbits but is not a skin sensitizer in guinea pigs. (API 1984, 1985a, 1986d)

Gasoline Unleaded gasoline (API PS-6) is similar to its component blending streams. It is not acutely toxic by the oral (rat > 18.75ml/kg [14g/kg]), dermal (rabbit > 5ml/kg [3.9g/kg]) routes and is not irritating to the rabbit eye 24 hrs after exposure. It is a mild skin irritant in rabbits and is not a skin sensitizer in guinea pigs. (API 1980a)

Conclusion: Results of testing naphtha blending streams for acute toxicity indicate that these materials demonstrate consistently low toxicity by the oral [Rat LD50 >5g/kg], dermal [Rabbit LD50 >2g/kg] and inhalation [Rat LC50 >5g/m^3] exposure routes, are mild to moderate eye and skin irritants and are not skin sensitizers. Acute data for gasoline gave comparable results. The inhalation acute toxicity read-across value for untested category members is LC50 > 5g/m^3

7.1.2. Repeated Dose Toxicity

Key inhalation studies are described in detail below. The focus is on inhalation studies as inhalation is the most relevant route for human exposure. Studies by the dermal route are summarized in the Supplemental Studies section**.**

Light alkylate naphtha (LAN, CAS #64741-66-8; approx 100% paraffinic) has been tested as a vapor distillate fraction (approx. 100% paraffinic) by inhalation in the rat for systemic toxicity and neurotoxicity, and in the rabbit by dermal exposure.

Sprague Dawley rats [12males/12 females/group] were exposed to a LAN light end distillate at concentrations of 0, 668, 2220, and 6646ppm (2438, 8102 and 24300mg/m^3), 6 hours/day, 5 days/wk for 13 weeks, according to OECD guideline 413. The test material (LAN-D) was prepared to be representative of the fraction of light alkylate naphtha to which man would be exposed during normal handling and use. It was obtained by the distillation of light alkylate naphtha (LAN) and collection of that fraction that boiled over the temperature range 78 to 145°F. The maximum exposure level was 75% of the lower explosive limit for LAN distillate. Extra groups of 12 rats of each sex exposed to the high dose level and a recovery control group were maintained untreated for 28 days following cessation of the 13 weeks exposure. Neurobehavioral evaluations of motor activity and functional activity [FOB] were performed pretest and during weeks 5, 9, 14 and week 18 for recovery groups. Animals were not exposed to LAN-D during these tests. Ophthalmoscopic evaluations were performed pretest and just prior to the scheduled sacrifices at 14 weeks and18 weeks (recovery groups). Body weights and food consumption were measured throughout the study. Blood samples were taken from 12 fasted rats/sex/group at 14 and 18 weeks for hematological and clinical chemical measurements. At termination (after 13 weeks exposure for the main study and after 18 weeks for the recovery animals) all animals were killed and subjected to a complete macroscopic examination. The following organs were weighed: adrenals, brain, heart, kidneys, liver, lung, ovaries, prostate, spleen, testes (with epididymides), thymus and uterus. Brain lengths and widths were measured for each rat. Thirty nine tissues removed from the control and high dose animals, were fixed, stained with hemotoxylin-eosin and examined histopathologically. Additionally, kidneys from selected animals were stained with Mallory-Heidenhain and examined. Tissues were collected from the nervous system (central and peripheral) of all animals and nervous system tissues were selected randomly from 6 rats per sex/group in the high dose and controls at the end of 13 weeks for microscopic examination. Specific brain regions examined were forebrain, cerebral cortex, hippocampus, basal ganglia, midbrain cerebellum and pons and medulla.

Neurobehavioral studies included motor activity, monitored as the number of beam breaks in an activity box, at pretest, and during weeks 5, 9, 14, and at the end of the 4- week recovery period. The Functional Operational Battery [FOB] was comprised of home cage evaluations, handling and open field behaviors and reflex assessment. Animals were also evaluated for fore limb and hind limb grip strength, landing foot splay and air righting ability.

There were no mortalities during the study and there were no treatment related signs of toxicity with the possible exception of an increased incidence of red facial staining in rats of both sexes in the high dose group. Mean body weights, body weight gains and food consumption were unaffected by treatment. Hematologic changes were a 5% decrease in hemoglobin and a 7% decrease in erythrocyte counts. Hemoglobin was still decreased 4% after the 4 week recovery period. However all these decreases were small and within historical control range for the laboratory. Decreases in AST and ALT in high dose females were not considered toxicologically significant because several control females had AST and ALT levels that were elevated relative to the other control females and relative to the historical control range.

Comparison of values from high dose females with these elevated control values indicates that some were different by statistical criteria, but these differences were not toxicologically important. Organ weight changes were few. Statistically significant increases in kidney weights in high dose males correlated with microscopically observed hyaline droplet formation and degeneration of proximal renal tubules were observed, indicative of alpha 2-microglobulin mediated nephropathy, also identified as light hydrocarbon nephropathy, a species and sex specific syndrome not relevant to humans (US EPA, 1991). Increased liver weights in high dose rats of both sexes had no microscopic correlate and appeared reversible after 4 weeks of recovery. Absolute and relative liver weights were observed in the high dose males and females at 13 weeks but the differences had disappeared after the recovery period. There were no pathological findings associated with this increase. In the neurobehavioral studies no treatment-related effects were observed in the functional operational battery. In the study of motor activity there were some statistically significant differences, but overall they did not occur in a dose related manner and furthermore were smaller than some of the differences seen during the pre-dosing period. The systemic LOAEL = 6646ppm (24300mg/m^3) based on increased liver weight and red facial staining and the NOAEL = 2220ppm (8200mg/m^3). The Neurotoxicity NOAEL = 6646ppm (24300mg/m^3). (Schreiner et al., 1998)

Light catalytic cracked naphtha (LCCN, CAS #64741-55-5, approximately 46% olefinic) was tested by inhalation in three 13-week studies and one 21-day study. In the three 13 week studies, concentrations were 147 - 2136ppm (530-7690 mg/m^3) partially vaporized LCCN to rats and mice (Dalbey et al, 1996); 1500 – 4500ppm (5474-16423 mg/m^3) wholly vaporized LCCN to rats (API, 1987d); and 750 – 7500ppm (2336-23364 mg/m^3) light ends distillate to rats (Lapin et al., 2001). In the 21-day study (15 actual exposures), wholly vaporized LCCN was administered to male and female Sprague Dawley rats at concentrations of 55, 567, and 3628ppm (200, 2040, and 13060mg/m^3) (Halder et al., 1984). Only kidney effects in male rats were reported in detail in the Halder et al. studies [see Supplemental studies below]. Of the three 13 week studies, two discussed in detail here most accurately reflect effects of exposure to LCCN.

Sprague Dawley rats [16 males/16 females/group] were exposed to an LCCN light end distillate (approx. 60% olefinic) at concentrations of 0, 750, 2500, and 7500ppm (2340, 7700 and 23400mg/m^3), 6 hours/day, 5 days/wk over 15 weeks, according to OECD guideline 413, for a total duration of at least 65 exposures. The test material (LCCN-D) was prepared to be representative of the fraction of light catalytic cracked naphtha to which man might be exposed during normal handling and blending. The maximum exposure level was 75% of the lower explosive limit for LCCN distillate. Extra groups of 16 rats of each sex exposed to the high dose level and a recovery control group were maintained untreated for 28 days following cessation of the 15 weeks exposure. Neurobehavioral evaluations of motor activity and functional activity [FOB] were performed pretest and during weeks 5, 9, 15 and 19 for recovery groups. Animals were not exposed to LCCN-D during these tests. Ophthalmoscopic evaluations were performed pretest and just prior to the scheduled sacrifices at 15 weeks and 20 weeks (recovery groups). Body weights and food consumption was measured throughout the study. Blood samples were taken from 10 fasted rats/sex/group at 14 and 18 weeks for hematological and clinical chemistry measurements. At termination (after 15 weeks exposure for the main study and after 19 weeks for the recovery animals) all animals were killed and subjected to a complete macroscopic examination. Ten rats/sex/group were selected for non-neuropathologic examination and 6 rats/sex/group for neuropathologic examination. The following organs were weighed from the non-neuropathologic animals: adrenals, brain, heart, kidneys, liver, lung, ovaries, prostate, spleen, testes (with epididymides), thymus and uterus. Brain lengths and widths were measured for each rat. Thirty-nine tissues removed from the

control and high dose animals, fixed and examined histopathologically. Additionally, kidneys from selected animals were stained with Mallory-Heidenhain and examined. Tissues were collected from the nervous system (central and peripheral) of all animals and nervous system tissues were selected randomly from 6 rats per sex/group in the high dose and controls at the end of 15 weeks for microscopic examination. Specific brain regions examined were forebrain, cerebral cortex, hippocampus, basal ganglia, midbrain cerebellum and pons and medulla.

Neurobehavioral studies included motor activity, monitored as the number of beam breaks in an activity box, at pretest, and during weeks 5, 9, 14, and at the end of the 4 week recovery period. The Functional Operational Battery [FOB] was comprised of home cage evaluations, handling and open field behaviors and reflex assessment. Animals were also evaluated for fore limb and hind limb grip strength, landing foot splay and air righting ability.

No exposure-related clinical observations were noted either during exposure or during non-exposure periods and no ocular abnormalities were observed. Slight differences in weight gain were seen in high dose animals but weights were comparable to controls at the end of the recovery period. During the 4-week recovery period, the high dose males and females had food consumption that was greater (statistically significant) than controls. At 15 weeks, hematologic changes in the high dose group were decreased hemoglobin (8%) and hematocrit (7%) in males and decreased MCHC (3%) in females and in the mid-dose group males decreased MCHC (4%). After 4 weeks recovery, all hematologic values were comparable to controls. No abnormal clinical chemistry values were observed after 15 weeks exposure. Although glucose and albumin levels were elevated in high dose females after the recovery period, the values fell within normal historical range and were not considered toxicologically significant. Statistically significant increases in absolute and relative kidney weights in high dose males and relative kidney weights in mid-dose males correlated with microscopically observed hyaline droplet formation and degeneration of proximal renal tubules in high dose males, indicative of alpha 2-microglobulin mediated nephropathy, also identified as light hydrocarbon nephropathy, a species and sex specific syndrome not relevant to humans (US EPA, 1991). Increased relative liver weights in high dose rats of both sexes had no microscopic correlate, although the absolute liver weight in recovery high dose females was elevated possibly correlated with increased food consumption. Decreased relative brain weight in recovery females had no microscopic correlate. With the exception of kidney findings in males, the only treatment related microscopic observations were nasal mucosa hyperplasia and hypertrophy/ hyperplasia of goblet cells indicative of exposure to a mild irritant, the incidence of which was comparable to controls after the recovery period.

In the neurobehavioral studies there was no evidence of any effect on motor activity either after 15 weeks exposure or after the 4-week recovery period. There was no evidence of a treatment-related effect in the functional operational battery. The systemic toxicity LOAEL = 7500ppm (23400mg/m^3) based on increased organ weight and nasal epithelium changes and the NOAEL = 2500ppm (7700mg/m^3). The Neurotoxicity NOAEL = 7500ppm (23400mg/m^3). (Lapin et al., 2001)

A 13 week inhalation study was conducted in Sprague Dawley rats [10/sex/group] and CD-1 mice [10/sex/group] exposed to a 40% vapor of LCCN at concentrations of 0, 147, 572, 2136ppm (0, 530, 2060 & 7690 mg/m^3), 6 hours/day, 5 days/week. Extra groups of 10 rats and mice of each sex served as sham and untreated controls. Food and water was available ad-lib, except during the exposure periods. Clinical observations were made regularly and body weights were recorded weekly. At the end of the 13 weeks exposure, blood was drawn from fasted animals for hematological and clinical chemistry measurements. All animals were then sacrificed and necropsied. Organs were weighed and a wide range of tissues fixed for

subsequent histology and microscopic examination. The wet and dry weights of the right apical and right middle lung lobes were also recorded. The cauda epididymis of the control and high dose male rats was used to determine the morphology and number of sperm and the left testis was used to determine the number of testicular spermatids. The following tissues from the high dose and sham treated animals were examined histologically: adrenals, kidney, bone and marrow (sternum), pancreas, brain, submaxillary salivary gland, eye, optic nerve, spleen, heart, stomach, colon, testes or ovaries, duodenum, kidneys, thymus, thyroid, liver, tracheobronchial lymph nodes, lung (left lobe), nasal turbinates, muscle, urinary bladder, sciatic nerve, and any gross lesions. Additional sections included lung from untreated controls and kidney from 0, 572 and 2136ppm (2060 and 7690 mg/m^3) exposure groups.

No treatment-related changes were observed in either species in clinical signs, body weight, clinical chemistry or hematology except four male rats in the high dose group that had lesions on the skin in the scrotal area. This was attributed possibly to an interaction between abrasions of the skin against the floors of the cages and the whole-body exposure to high concentrations of LCCN. Organ weights were unaffected in either species, except for uterus weights. Uterine weights in the rats were less than untreated controls for all exposed groups, but not less than the sham controls. Uterine weight changes were not considered to be related to LCCN because they were not dose-related, and there was no difference between the sham and untreated controls. Additionally, no similar effect was observed in the mice. No treatment-related abnormalities were observed in any of the organs examined microscopically. The occurrence of hyaline droplets in dilated renal tubules was similar in the controls and the high dose male rats. The number of sperm per gram of cauda epididymis was significantly lower in the 2136ppm (7690 mg/m^3) rat group than in the sham controls but not the untreated controls. The actual number of epididymal sperm was not significantly affected by exposure. Also, the number of testicular spermatids and the percentage of abnormal sperm in the cauda epididymis were not affected by exposure to 2136ppm (7690 mg/m^3) in rats compared to either control group. The toxicological significance of the decrease in sperm/gram in the epididymis is unknown since it was not supported by other male parameters, but the occurrence has been used to set the LOAEL. The rat systemic toxicity LOAEL = 2136ppm (7690 mg/m^3) NOAEL = 572ppm (2060 mg/m^3). The mouse systemic NOAEL = 2136ppm (7690 mg/m^3). (Dalbey et al, 1996)

Another 13 week inhalation study on a high olefinic test material similar to those used in the Dalbey et al (1996) and Lapin et al (2001) studies conducted in rats at exposure concentrations of 1510, 2610, 4520 ppm (0, 5475, 9500, -16425 mg/m^3) had results similar to the Lapin et al study. Additionally, a trace centrilobular hepatocellular hypertrophy was observed in 50% of the males and 25% of the females in the 4520 ppm group. This study was performed at vapor concentrations above that of the 40% vapor study of Dalbey et al, and did not show any effects on sperm numbers in the epididymis. (API 1987d).

The 21 day inhalation study set of Halder et al, 1984 confirmed the findings in male kidneys that had been observed in other studies with rats [see Supplemental studies below]. However, since these kidney effects are not considered relevant to man and study duration is less than the 13 week studies, this is not considered a key study and is not included in establishing toxicity ranges. Only abbreviated robust summaries are supplied.

Heavy straight run naphtha (CAS # 64741-41-9, HNN, approximately 30% naphthenic) was tested by inhalation in an OECD 422 Combined Repeated Dose Toxicity Study with the Reproductive/Developmental Toxicity Screening Test. General study procedures and the result of the systemic repeated dose section are presented here. Details of the reproductive/developmental segment are found in Section 7.1.5. Concentrations of HNN were

generated by flash evaporation of the test material. Groups of male and female Sprague Dawley rats [12/sex/group] were exposed to 0, 100, 500 or 3000ppm (0, 455, 2275, or 13650mg/m^3) for 30 [males] and 31 [female] days. Satellite groups of 12 young, nulliparous, nonpregnant female rats were exposed to 0, 100, 500, or 3000 ppm during a premating period of approximately 2 weeks, a cohabitation period of approximately 2 weeks, and a gestation period of approximately 3 weeks. The animals were not exposed after gestation day 19, or during the approximately 4-day lactation period. Females without evidence of mating continued to be exposed for 26 days after the end of the cohabitation period. Body weights, clinical signs, and food consumption were recorded throughout the study. After approximately 30 days, from all male and all subchronic female rats and on lactation day 4 from satellite females, blood samples were collected for haematology and clinical chemistry measurements. An abbreviated neurobehavioral evaluation was conducted on all males, subchronic females, and satellite females prior to test substance administration in order to obtain baseline measurements, and again following approximately 4 weeks of test substance administration for males and subchronic females and on lactation day 4 for satellite females. Neurobehavioral evaluation consisted of motor activity and a modified Functional Observational Battery [FOB] of open field (approach and touch response, auditory response and tail pinch), papillary response, and fore and hind limb grip strength. Males and subchronic females were sacrificed after approximately 30 days of exposure, organs (liver, kidneys, lungs, adrenal glands, thymus, brain, spleen, heart, testes with epididymides, prostate, ovaries with oviducts, and uterus with cervix) were weighed, and 36 selected tissues were evaluated microscopically. On postpartum day 4, lactating females and offspring were sacrificed, organs (liver, kidneys, lungs, ovaries with oviducts and uterus with cervix) were weighed, and reproductive organs were evaluated microscopically. Offspring were evaluated for external abnormalities.

Mortality did not occur at any exposure concentration. Test substance-related increases in the incidence of stained and wet fur in males, subchronic females, and satellite females were observed in the 3000ppm group; however, they did not adversely impact the health of the animals. Adverse, test substance-related, decreases in body weight, weight gain, and food efficiency occurred in 3000ppm subchronic females. Slightly decreased body weight and/or weight gain occurred in 3000ppm males and satellite females; however, the magnitude of the effects was not statistically significant. There were no adverse or test substance related effects on neurobehavioral parameters, haematology or clinical chemistry parameters. Liver weight parameters were increased in 3000ppm males and subchronic females, which correlated with hepatocellular hypertrophy. Kidney weight parameters were increased in 500ppm and above males and in 3000ppm subchronic females. In males, the increased absolute/relative kidney weights correlated with hyaline droplet accumulation observed in 100ppm and above males, indicative of alpha 2-microglobulin mediated nephropathy also identified as light hydrocarbon nephropathy, a species and sex specific syndrome not relevant to humans (US EPA, 1991). In 3000ppm subchronic females, the increased kidney weight parameters were not associated with any functional or microscopic change, and therefore were considered secondary to non-adverse enzyme induction. Minimal hypertrophy of thyroid follicular epithelium occurred in 3000ppm males and subchronic females, possibly secondary to liver enzyme induction The systemic toxicity LOAEL exclusive of kidney effects = 3000ppm (13650mg/m^3) based on decreased body weight, weight gain and decreased food efficiency in females and hypertrophy of thyroid follicular epithelium in 3000ppm animals of both sexes. The systemic NOAEL excluding male kidney effects = 500ppm (2275mg/m^3). The Neurobehavioral NOEL = 3000ppm (13650mg/m^3). (API, 2008a)

Full range catalytic reformed naphtha (CAS # 68955-35-1, FR-CRN, approximately 63% aromatic) was tested as a 30-40% vaporized sample in Sprague Dawley rats [15 rats/sex/group] at nominal concentrations of 0, 96, 464, 1894ppm (0, 410, 1970 and 8050 mg/m^3), 6 hours/day, 5 days/week. Two extra groups of 15 rats/sex served as sham and untreated controls. Water was available ad lib, but food was withheld during the exposure periods. Clinical observations were made regularly and body weights were recorded weekly. At the end of the 13 weeks exposure, blood samples were taken for hematological and clinical chemistry measurements. The rats were then sacrificed and necropsied. Organs were weighed and a wide range of tissues fixed for subsequent histology and microscopic examination. The wet weight of the right middle lung lobe was also weighed. The lobes were then dried and their dry weights determined. The cauda epididymis of the control and high dose male rats was used to determine the morphology and number of sperm and the left testis was used to determine the number of testicular spermatids. The following tissues from the high dose animals were examined histologically: adrenals, bone and marrow (sternum), pancreas (head), brain (three sections), submaxillary salivary gland, eye, optic nerve, spleen, heart, stomach (squamous and glandular), colon, testes or ovaries, duodenum, kidneys, thymus, thyroid, liver, tracheobronchial lymph nodes, lung (left lobe), nasal turbinates (four sections), thigh muscle, urinary bladder, sciatic nerve, and any gross lesions. In addition, tracheobronchial lymph nodes and any gross lesions from untreated control animals were also evaluated.

There were no treatment-related clinical signs during the study. No effects on serum chemistry values or parameters of the male reproductive system at terminal sacrifice were reported. Body weights of males exposed at the mid and high dose were higher than the controls throughout the study and the differences were statistically significant in the high dose group from week 10 onwards. WBC count was significantly lower in sham treated controls and all three treated groups in both sexes compared to untreated controls. Additionally the WBC count was decreased by approximately 24% in the high dose females when compared to the sham controls. No other parameters were affected. The only organ weights affected were the liver and kidney. In the male high dose group, mean kidney weight was approximately 13% greater than the sham treated animals (but not the untreated controls), and the liver weight was approximately 14% greater. No treatment-related gross lesions were observed at necropsy and no treatment-related abnormalities were noted during microscopic examination. The results of this study are consistent with the study performed with the light catalytic reformed naphtha distillate fraction.

The LOAEL = 1894ppm (8050mg/m^3) based on increased liver and kidney weights in males, decreased WBC in females. NOAEL = 464ppm (1970mg/m^3). (Dalbey and Feuston, 1996).

Light catalytic reformed naphtha (CAS #64741-63-5, LCRN, 33% aromatic) was tested as a light end distillate in Sprague Dawley rats [16 males/16 females/group] at concentrations of 0, 750, 2500, and 7500ppm (0, 2775, 9250 and 27750mg/m^3), 6 hours/day, 5 days/wk over 15 weeks, according to OECD guideline 413, for a total duration of at least 65 exposures. The test material (LCRN-D) was prepared to be representative of the fraction of light catalytic reformed naphtha to which man might be exposed during normal handling and blending. The maximum exposure level was 75% of the lower explosive limit for LCRN distillate. Extra groups of 16 rats of each sex exposed to the high dose level and a recovery control group were maintained untreated for 28 days following cessation of the 15 weeks exposure. Neurobehavioral evaluations of motor activity and functional activity [FOB] were performed pretest and during weeks 5, 9, 14 and 19 for recovery groups. Animals were not exposed to LCRN-D during these tests. Ophthalmoscopic evaluations were performed pretest and just prior to the scheduled sacrifices at 14 weeks and 19 weeks (recovery groups). Body weights and food consumption

was measured throughout the study. Blood samples were taken from 10 fasted rats/sex/group at 14 and 18 weeks for hematological and clinical chemical measurements. At termination (after 13 weeks exposure for the main study and after 19 weeks for the recovery animals) all animals were killed and subjected to a complete macroscopic examination. Ten rats/sex/group were selected for non-neuropathologic examination and 6 rats/sex/group for neuropathologic examination. The following organs were weighed from the non-neuropathologic animals: adrenals, brain, heart, kidneys, liver, lung, ovaries, prostate, spleen, testes (with epididymis), thymus and uterus. Brain lengths and widths were measured for each rat. Thirty-nine tissues removed from the control and high dose animals, fixed, stained with hematoxylin eosin and examined histopathologically. Additionally, kidneys from selected animals were stained with Mallory-Heidenhain and examined. Tissues were collected from the nervous system (central and peripheral) of all animals and nervous system tissues were selected randomly from 6 rats per sex/group in the high dose and controls at the end of 15 weeks for microscopic examination. Specific brain regions examined were forebrain, cerebral cortex, hippocampus, basal ganglia, midbrain cerebellum and pons and medulla.

Neurobehavioral studies included motor activity, monitored as the number of beam breaks in an activity box, at pretest, and during weeks 5, 9, 14, and at the end of the 4-week recovery period. The Functional Operational Battery [FOB] was comprised of home cage evaluations, handling and open field behaviors and reflex assessment. Animals were also evaluated for fore limb and hind limb grip strength, landing foot splay and air righting ability.

There were no mortalities during the study and there were no treatment-related signs of toxicity. The ophthalmic examinations did not reveal any treatment-related effects. Mean body weights, body weight gains and food consumption were unaffected by treatment. After 13 weeks exposure there was a significant decrease in total WBC count (36%) and lymphocyte counts in the high dose males and a slight decrease in neutrophil counts for the mid dose males. A trend towards decreased WBC (2.1%) and lymphocyte counts was also seen in the mid dose males and high dose females. After the 4 week recovery period, leukocyte values were comparable to control values. However, MCV was slightly decreased (2.8%) in the high dose males. It was concluded that these changes were suggestive of a reversible slight effect of the LCRN-D. Clinical chemistry parameters were unaffected by treatment. After 13 weeks exposure relative kidney weights in the high dose males were increased (15.9%) and this correlated with the occurrence of hyaline droplets in the proximal convoluted tubules. This finding has been described as alpha 2-microglobulin mediated nephropathy, also identified as light hydrocarbon-induced nephropathy and is sex and species specific and is not relevant for human health risk assessment. (US EPA, 1991) In the high dose males decreased absolute (25.7%) and relative (22%) spleen weights were also recorded. It was concluded that this was associated with the minor hematological changes that had been observed. These differences were not apparent after the recovery period and no abnormal microscopic findings were found in either the spleen or bone marrow.

No treatment-related effects were recorded in the Functional Operational Battery. In the examinations of motor activity, there were no treatment-related effects recorded during the 13-week exposure period but a slight increased activity was found in the high dose males after the 4-week recovery period. Brain length and width measurements were unaffected by treatment and there were no abnormal microscopic findings in the brain, spinal cord or peripheral nerves. The systemic toxicity LOAEL exclusive of kidney effects = 7500ppm 927750mg/m^3) based on decreased WBC and lymphocyte counts, and decreased male spleen weight. The systemic NOAEL = 2500ppm (9250mg/m^3). The Neurobehavioral NOEL = 2500ppm (9250g/m^3) due to increased motor activity in high dose recovery males. (Schreiner et al., 2000)

Supplemental studies

In the 21 day inhalation studies, male Sprague Dawley rats were exposed to a light reformate naphtha (31% aromatics) and a heavy reformate naphtha (93% aromatics) at concentrations of 0, 544, 1591, and 5522ppm (0, 2000, 5850 and 20300mg/m^3) LCRN or 0, 215, 587, and 2132ppm (1030, 2810, and 10200mg/m^3) HCRN for 15 actual exposures. These studies focused on nephropathy in male rats; other systemic effects are not described in detail in the publication. Alpha 2-microglobulin mediated nephropathy also identified as light hydrocarbon induced nephropathy in male rats is sex and species specific; it does not occur in female rats or other species, including humans. Alpha 2-microglobulin mediated nephropathy is not relevant to human hazards (US EPA, 1991). LCRN induced small concentration related increases in necrosis of renal tubules and an increase in incidence and severity of hyaline droplets, typical of alpha 2-microglobulin mediated nephropathy. The exposure levels at which they occur are not included in establishing ranges for inhalation repeat dose toxicity. Exposure to HCRN did not cause adverse effects in the kidney but lung irritation was apparent. Results indicate that naphthas high in aromatics do not induce hydrocarbon nephropathy in male rats. (Halder et al., 1984).

Dermal studies:

Dermal treatment of New Zealand White rabbits, 3 times/week for 4 weeks with **Light alkylate naphtha** (LAN, CAS #64741-66-8, approximately 1000% paraffinic) at concentrations of 200, 1000, and 2000mg/kg/day on the shaved backs of rabbits resulted in mild skin irritation at the lowest dose and moderate skin irritation at the mid and high doses in both sexes, in association with granulopoiesis of bone marrow in the highest dose group. Significantly lower body weights were observed in both sexes at 2000mg/kg; organ wt changes included increased adrenal weights in males and decreased ovary weight in females at the highest dose. Adrenal weight changes and granulopoiesis are related to skin irritation induced stress. (API, 1986e)

Light catalytic cracked naphtha (LCCN, CAS #64741-55-5, approximately 46% olefinic) was tested for 13 weeks in Sprague Dawley rats. LCCN was applied undiluted to the clipped backs of rats (15/sex/group) at concentrations of 0, 30, 125 or 3000mg/kg/day, 5 days/week for 90 days. Rats were fitted with Elizabethan collars to minimize ingestion of test material. Percutaneous absorption was assessed by applying LCCN containing radiolabeled n- octane in a non-occlusive Bronaugh cell to untreated animals and animals treated for 90 days with cold LCCN. The percent of applied dose was recovered in urine, feces and tissue over 96 hours. No systemic toxicity expressed as changes in body or organ weights, clinical observations, hematology or clinical chemistry parameters, gross pathology or histopathology with the exception of skin irritation at treated sites resulted from exposure to LCCN. Sperm morphology in treated rats was comparable to controls. Skin irritation, erythema and edema at treated sites and histopathologic correlates of hyperplasia, inflammation and ulceration in all groups in a dose related pattern were the only effects reported. Approximately 1% radiolabeled LCCN penetrated the skin over 96 hours. Bioavailability was similar for untreated rats and those pre-treated for 90 days with LCCN. (Mobil 1988a)

Full range catalytic reformed naphtha (FR-CRN CAS # 68955-35-1, approximately 63% aromatic) was tested in a 28-day dermal study. FR-CRN was applied to the shaved backs of New Zealand White rabbits, 3 times a week for 4 weeks at doses of 200, 1000 and 2000mg/kg/day. Three males (2 high dose, 1 mid dose) died. The kidneys of the two high dose animals contained slight to moderate tubular degeneration. FR-CRN was a moderate-severe skin irritant. Inhibition of body weight and weight loss occurred at 2000mg/kg. Some differences observed between the control and treated groups for a few hematological and clinical chemistry parameters fell within the normal range for the laboratory, and were not regarded as treatment

related. Histopathologic examination revealed slight-moderate proliferative and inflammatory changes in skin at the highest dose concurrent with granulopoiesis of bone marrow, attributed to stress and other factors associated with skin irritation. No other significant findings were reported. LOAEL = 2000mg/kg/day based on decreased body weight and weight loss, irritation; NOAEL excluding I death = 1000mg/kg/day. (API, 1986f)

Six naphtha streams were tested in a series of 28 day dermal irritation pilot studies with Sprague Dawley rats. The test materials were: Hydrodesulfurized heavy naphtha (CAS #64742-82-1; UBTL, 1992a); Heavy reformate naphtha (CAS # 64741-68-0; UBTL 1992b), Sweetened naphtha (CAS #64741-87-3; UBTL 1994a), Full range coker naphtha (Merox Feed F-250, CAS # 68513-02-0; UBTL, 1994b) and two naphtha streams without CAS numbers – Light naphtha Isohexane Rich (UBTL, 1992c) and Light naphtha N-hexane rich (UBTL, 1992d). The test materials were applied undiluted to the clipped backs of Sprague Dawley rats (10/sex/group) at concentrations of 0, 0.05, 0.25 and 1.0ml/kg followed by 6 hours occlusion, 5 days/week for 4 weeks. Slight to moderate skin irritation in a concentration-related progression from low to high dose was seen in all studies at clinical observation and confirmed with histopathological evaluation. No other significant adverse effects in clinical signs, body weight, organ weights, hematology or clinical chemistry parameters or histopathology were observed. Although animals treated with full range coker naphtha demonstrated changes in hematology (% neutrophils, lymphocytes), clinical chemistry (globulin levels and albumin/ globulin ratio) and myeloid hyperplasia in bone marrow and lymph node hyperplasia, these effects were considered secondary to the severity of dermal irritation and not a direct effect of the test material. The NOEL level for systemic toxicity for all streams was 1.0ml/kg, the highest concentration tested in each study.

Gasoline

Thirteen week inhalation toxicity studies were performed with wholly vaporized leaded and unleaded gasoline at target concentrations of 0, 100 and 400ppm, or 0, 400, 1500ppm (0, 1570, 6350 mg/m^3) [actual concentrations: 0, 384, 1552ppm; (0, 1507, 6570 mg/m^3)] respectively, in Sprague Dawley rats and squirrel monkeys (Kuna and Ulrich, 1984). Only the results of the unleaded gasoline studies are relevant to the HPV program. Twenty rats and 4 monkeys of each sex were housed in 1m^3 glass and stainless steel exposure chambers 24 hours a day and were only removed for cleaning purposes. Blood was taken from 10 rats of each sex at the end of the study from the highest dose groups only for hematological evaluation. Blood was taken from all monkeys in the highest dose group at 1.5, and 3 months. Urine samples were analyzed for all animals at 1.5 and 3 months for levels of protein, glucose, ketones, bilirubin, and blood. CNS measurements and pulmonary function tests were performed on monkey and are summarized in the robust summary. All animals that died or were sacrificed at termination of the study were subjected to a gross necropsy. Organ weights were recorded and lungs, kidneys, spleen, heart, brain and bone marrow from the control and high dose groups were evaluated for histopathology. All male and female animals from the control and high exposure groups were also evaluated for the presence of IgG in the renal glomerulus and lungs.

Alpha 2-microglobulin mediated nephropathy also identified as light hydrocarbon induced nephropathy was observed in kidneys of all examined male rats exposed to leaded or unleaded gasoline but not in kidneys of squirrel monkeys. In rats, slight increases in thrombocyte and reticulocyte counts and liver weights of high dose males occurred with exposure to both gasolines, with increases in tissue and urinary lead levels for animals given leaded gasoline. Monkeys showed a small increase in respiratory rate with exposure to the highest concentration of unleaded gasoline, 6570mg/m^3.

Unleaded gasoline LOAEL, excluding alpha 2-microglobulin mediated nephropathy = 1552ppm (6570mg/m^3) based on increases in thrombocytes and reticulocytes, increased liver weights in males; NOAEL = 384ppm (1507mg/m^3)

Baseline Gasoline Vapor Condensate [BGVC], a 20% light fraction of a whole unleaded gasoline sample was evaluated in a 13- week inhalation study according to OPPTS 870.3465. This test material was a representative evaporative emission tested under the US EPA 211(b) Fuels and Fuel Additives Health Effects Testing Program (1994b, 1998). BGVC was administered to Sprague Dawley rats (10/sex/group) at target concentrations of 0, 2000, 10000, and 20000mg/m^3 (actual concentrations 0, 2050, 10,153 and 20,324 mg/m^3) 6hr/day, 5 days/week for 13 weeks. Additional groups of control and high dose rats (10/sex/group) were also exposed and retained untreated for an additional 4- week recovery period (API, BGVC, 2005b). Clinical signs, body weights and body weight changes, and food consumption were recorded throughout the study. Opthalmoscopic evaluations were performed pretest and at exposure termination. Hematology, coagulation and clinical chemistry parameters were measured at week 4 and week 13. Neurobehavior evaluation of motor activity and functional activity [FOB] were performed on 10 rats/sex/group pretest and during weeks 3, 7, and 12 of exposure according to OPPTS 870.6200. After 13 weeks exposure rats were sacrificed except for recovery animals sacrificed 4 weeks later. Fourteen selected organs were weighed. Histopathologic examination was performed on 31 tissues from rats in the control and high dose groups and on kidneys from rats in all groups. Five rats/sex/group were perfused for neuropathology and sections of brain, eye, spinal cord, peripheral nerves and ganglia were examined microscopically. Satellite groups of animals were exposed to BGVC with the subchronic rats for immunotoxicology, genetic toxicity and glial fibrillary acidic protein (GFAP) analyses. The genetic toxicology studies are presented in Section 7.1.4 of this document. The immunotoxicology and GFAP report details are provided in robust summaries, and are not considered further here other than to state that BGVC was not toxic in these two satellite studies.

Test animals were generally unremarkable in exposure chambers and during non-exposure periods except for a slight increase in red nasal discharge seen in 20324mg/m^3 animals during 13 weeks of exposure but not during recovery. No adverse effects were induced by BGVC on ophthalmology, body weights, feed consumption or blood chemistry parameters. No toxicologically significant changes were observed in organ weights although male absolute and relative kidney weights were slightly elevated at the mid and high dose levels. Gross abnormalities were not seen at terminal sacrifice. Dose related microscopic findings included eosinophilic material in the nasolacrimal ducts in high dose rats consistent with reported red nasal discharge and renal histopathologic changes in kidneys of all treated male rats. These renal changes were consistent with alpha 2-microglobulin mediated nephropathy, a species and sex-specific change not considered relevant to human health (US EPA, 1991). Kidneys of recovery 20324mg/m^3 male rats had nearly complete resolution of these changes. BGVC did not cause adverse neurobehavioral or neuropathologic effects. The systemic LOAEL [excluding male kidney effects] = 20324mg/m^3 and NOAEL = 10153mg/m^3. NOAEL for neurotoxicology = 20324mg/m^3. The NOAEL/LOAEL values for this material are similar to those reported for refinery streams in the 4 chemical classes.

Conclusion: Results of repeated dose studies have demonstrated fairly similar profiles of toxicity across the 4 chemical classes. Inhalation studies which reflect the most relevant route of human exposure were performed with distillates prepared from the range of likely human

exposure or as vapor generated directly from the liquid blending stream. Because of limitations imposed by the lower explosive limits, vapor studies were performed at concentrations much lower than those possible with distillates. Exposure whether to distillate or vapor fractions could result in alpha 2-microglobulin mediated nephropathy in kidneys of male rats, also identified as light hydrocarbon induced nephropathy, a species and sex specific syndrome not relevant to human health (US EPA, 1991). Other systemic toxicity was minimal and in general, included increased weight of the liver in most studies and of spleen in one aromatic sample, and some decreases in body weight or small changes in clinical pathology parameters. One 40% vapor olefinic sample induced a decrease in sperm number per gram of epididymis, an effect not supported by other male parameters in this study or other studies. In studies where neurotoxicity was evaluated none of the streams induced significant neurobehavioral or neuropathologic effects.

Therefore, gasoline blending streams have a low inhalation repeat dose hazard potential. The inhalation NOAELs and LOAELs were similar between the different hydrocarbon classes of streams (PONA) and the formulated product, gasoline in rats. Since there were no appreciable differences between paraffinic, olefinic, naphthenic, and aromatic streams, a range of values derived from all of the repeated dose inhalation studies will be used to read across to all untested category members. These read-across values are:

LOAEL: 6572 mg/m^3 – 27,800mg/m^3 (1864 – 7885ppm[a])
NOAEL: 1507mg/m^3 – 10,153mg/m^3 (427 – 2880ppm[a])

[[a] - upper range of NOAEL based on 211(b) BGVC; Total hydrocarbon determined as parts-per-million (ppm) hexane equivalents.]

The majority of streams tested induced alpha 2-microglobulin mediated nephropathy in male rats. It has been demonstrated that this syndrome is specific for male rats, and does not occur in female rats or other species, including humans. Since this species and sex specific syndrome is not relevant to humans (US EPA, 1991), alpha 2-microglobulin mediated nephropathy has been excluded for developing LOAELs and NOAELs in all rat studies.

When applied dermally, gasoline blending streams induced skin irritation with the only systemic effects related to skin damage and accompanying stress.

7.1.3. Genetic Toxicity *In Vitro*

Light alkylate naphtha (LAN, approx. 100% paraffinic) diluted in acetone, has been tested in a mouse lymphoma (L5178Y TK+/-) forward mutation assay. For the mutation assay the lymphoma cells were exposed for 4 hours to test material at concentrations ranging from 0.005 to 0.08 µl/ml without activation and 0.00004 to 0.8 µl/ml with Aroclor-induced rat liver S-9 activation. After exposure to the test material, the cells were allowed to recover for 2 days and then cultures were selected for cloning and mutant selection; trifluorothymidine (TFT) was used as the restrictive agent. The non-activated cultures treated with 0.005 to 0.04µl/ml LAN were cloned, resulting in a range of growth of 6 to 97%. The activated cultures treated with 0.0002 to 0.75 µl/ml LAN were cloned, resulting in a range of growth from 24 to 109%. Plates were prepared from TFT-restricted and from the Viable cultures (VC) and after 10 to 12 days incubation these plates were scored for total number of colonies per plate. Several trials were performed to verify the absence of genetic toxicity in this assay system. Light alkylate naphtha did not induce mutagenicity with or without metabolic activation from rat liver homogenate. (API, 1985b)

Three samples of light catalytic cracked naphtha (LCCN, approx. 46% olefinic) have been tested in a mouse lymphoma (L5178Y TK+/-) forward mutation assay. The results for API 83-20 are described here (API, 1987e). A cytotoxicity study carried out prior to the mutagenicity assay established that LCCN was highly toxic at 500nl/ml without activation and lethal at the same concentration in the presence of metabolic activation. For the initial mutation assay the mouse lymphoma cells were exposed for 4 hours to LCCN at treatments from 50 to 800 nl/ml LCCN without activation and with treatments from 25 to 500 nl/ml LCCN with Aroclor-induced rat liver S-9 activation. After exposure to LCCN, the cells were allowed to recover for 2 days and then cultures were selected for cloning and mutant selection. Plates containing colonies of selected cells were incubated for 10 to 14 days after which they were scored for total number of colonies per plate. A mutation frequency was then determined. Due to a wide range of toxicity in the first assay with and without metabolic activation, a second assay was performed over a narrower dose range of 50 to 150nl LCCN without S9 activation and 200 to 300nl LCCN with activation. LCCN sample API 83-20 was not mutagenic with or without metabolic activation. Of the two other LCCN samples tested, one API 81-03 (API, 1985c) was not mutagenic and one API 81-04 (API, 1986g) was not mutagenic without metabolic activation but gave equivocal results with metabolic activation. Equivocal results are defined as a situation in which one or more doses exhibit a 2-fold mutant frequency greater than background level but there is no dose response. Overall LCCN is not considered mutagenic in this mammalian cell assay.

An *in vitro* sister chromatid exchange (SCE) assay in Chinese hamster ovary (CHO) cells with and without metabolic activation [a non-SIDs endpoint] was performed with LCCN. CHO cells were seeded in duplicate for each treatment condition and were incubated at 37°C in a humidified atmosphere for 16 to 24 hours. Treatment was carried out by re-feeding two complete sets of flasks with complete medium for the non activation study or with Aroclor-induced rat liver S-9 reaction mixture for the activated study to which was added 50 µl of dosing solution of test control or article in solvent or solvent alone. CHO cells were exposed to solvent alone and to nine concentrations of LCCN ranging from 1 to 0.0001µl/ml in the absence and presence of an S-9 reaction mixture. Based on the growth inhibition and cell cycle delay, dose levels of 0.3, 0.2, 0.1 and 0.05 µl/ml LCCN were selected for use in the assay without metabolic activation and at concentrations of 0.2, 0.1, 0.05 and 0.03 µl/ml LCCN in the assay with metabolic activation. A harvest time of 30 hours after treatment initiation was selected to assure collection of enough analyzable second division metaphases at the high dose. In the non-activation study the cells were exposed for 28 hours. Two hours after exposure 0.01 mM BrdU was added to the treatment medium. At the end of the treatment period, the treatment medium was removed, the cells were rinsed and were then exposed to colcemid (0.1µg/ml) for a further 2 hours. In the activation study exposure was for 2 hours. After the exposure period, the treatment medium was removed; the cells were washed with PBS, re-fed with medium containing BrdU and then incubated for a further 28 hours. Colcemid was added at a final concentration of 0.1µg/ml for the last 2 hours of incubation. For activated and non-activated assays, metaphase cells were harvested 2 hours after addition of colcemid. Cells were collected and fixed and stored until slides were prepared. Slides were coded and scored without regard to treatment group. Only cells with 20 ≤ 2 centromeres were selected for evaluation of SCEs. A total of 4 doses were scored including the highest test article dose where sufficient second-division metaphase cells were available. SCEs were scored in 25 cells from each duplicate culture to make up a total of 50 cells per treatment. The percentage of cells in first (M1), second (M2) or third division (M3) metaphase was also recorded for a total of 100 metaphase cells scored. Triethylenemelamine (TEM) was used as positive control at a concentration of 0.025 µg/ml. in the non-activated assay. In the activated assay cyclophosphamide (CP) was used at a concentration of 2.5µg/ml. API 81-03 did not induce an increase in sister chromatid exchanges

in CHO cells when tested in the absence of metabolic activation. However the test material did induce a small but statistically significant increase in SCEs at two intermediate dose levels in the presence of metabolic activation, a result that was concluded to be equivocal. (API 1988a)

Sweetened naphtha (SN, CAS # 64741-87-3; approx 21% naphthenic) diluted in ethanol, has been tested in a mouse lymphoma (L5178Y TK+/-) forward mutation assay. For the mutation assay the mouse lymphoma cells were exposed for 4 hours to SN at concentrations ranging from 0.005 to 0.08 µl/ml without activation and 0.00004 to 0.8 µl/ml with Aroclor-induced rat liver S-9 activation. After exposure to SN, the cells were allowed to recover for 2 days and then cultures were selected for cloning and mutant selection; trifluorothymidine (TFT) was used as the restrictive agent. The non-activated cultures treated with 0.005 to 0.04µl/ml SN and activated cultures treated with 0.0002 to 0.75 µl/ml SN were cloned and produced a range of growth from 24 to 109%. Plates were prepared from TFT-restricted and from the Viable cultures (VC) and after 10 to 12 days incubation these plates were scored for total number of colonies per plate. Five trials were performed due to wide ranges of toxicity and sporadic increases in mutant frequencies in order to verify the absence of genetic toxicity in this assay system. Overall Sweetened naphtha did not induce mutagenicity with or without metabolic activation from rat liver homogenate. (API, 1985d)

Three samples of catalytic reformed naphthas have been tested in a mouse lymphoma (L5178Y TK+/-) forward mutation assay. The results for API 83-05, a full range catalytic reformed naphtha (FRCRN, 63% aromatics) are described here. Other samples were a light catalytic reformed naphtha (LCRN, 42% aromatics) and a heavy catalytic reformed naphtha (HCRN, 90% aromatics). A cytotoxicity study carried out prior to the mutagenicity assay established that FRCRN was lethal to all cultures at 500µl/ml and highly toxic at 250 µl/ml. For the mutation assay the mouse lymphoma cells were exposed for 4 hours to FRCRN dissolved in acetone at treatments from 6.25 to 500 µl/ml without activation and at treatments from 3.13 to 400µl/ml with Aroclor-induced rat liver S-9 activation. After exposure to FRCRN material, the cells were allowed to recover for 2 days and then cultures were selected for cloning and mutant selection. Plates containing colonies of selected cells were incubated for 10 to 14 days after which they were scored for total number of colonies per plate. Cultures selected for cloning at doses of 6.25 to 100 µl/ml FRCRN without S-9 had growth rates of 30-97% and cultures selected for cloning with S-9 had growth rates of 4.6 to 67.9%. A mutation frequency was then determined. Full range catalytic reformed naptha was not mutagenic without metabolic activation but did induce dose related increases in mutant frequency with metabolic activation. (API, 1985e)

The light catalytic reformed naphtha containing 42% aromatics was not mutagenic with or without metabolic activation (API, 1985f). A heavy catalytic reformed naphtha containing 90% aromatics produced negative/equivocal results without metabolic activation and equivocal/positive results with metabolic activation in two separate laboratories (API, 1985g). Interestingly, this heavy catalytic reformed naphtha did not induce dermal tumors in a 2 year mouse skin painting study (see Section 7.2.1.2 Dermal Carcinogenesis). These results suggest that the aromatic content of these streams may influence the degree of mutagenic activity induced in this *in vitro* mammalian cell test system. However, the absence of dermal tumors from exposure to the heavy catalytic reformed naphtha in a two-year study indicates that the toxicological significance of the results of mouse lymphoma studies of CRN are unclear

Gasoline

Unleaded gasoline was tested in the Ames Microbial mutation assay in *Salmonella typhimurium* and *Saccharomyces cerevisiae* with and without metabolic activation from an Aroclor-induced rat liver homogenate mixture. Salmonella strains TA100, TA1535, TA1537, TA1538, TA98 and yeast strain D4 were employed. Based on preliminary cytotoxicity assays, concentrations of gasoline in dimethylsulfoxide were administered to all 5 Salmonella tester strains at doses of 0.375, 0.75, 1.5 and 3.0% and to yeast at doses of 0.625, 1.25, 2.5, and 5.0%. For plate assays, test material was added to cells in broth. The contents of the test tubes of broth plus test material were poured over selective agar plates. Plates were incubated at 37^0C for 48 hours, then removed from the incubator and revertant cells were counted. In the suspension tests, bacteria and yeast cultures were grown in complete broth. The cells were removed, washed and exposed to the test material. For the yeast cells exposure to gasoline was for 4 hours and bacterial cell exposure was for 1 hour. Aliquots of the cells were plated onto the appropriate complete media. After suitable incubation periods, the number of revertant colonies was counted.

In the plate test**,** there was no increase in revertant colonies caused by exposure to gasoline at any concentration. The results in this assay were negative both with and without metabolic activation. In the suspension test without activation, Slight increases were observed at the high dose levels with TA100, TA1537 and TA1538. However the responses were not adequate to be considered positive. The increases with TA98 could not be reproduced in a repeat trial. In the suspension test with activation, scattered increases were found at one or more dose levels but were not reproducible in a repeat trial. Therefore, gasoline was not a mutagen in this test system. (API, 1977a)

Gasoline diluted in acetone, has been tested in a mouse lymphoma (L5178Y TK+/-) forward mutation assay. For the mutation assay the lymphoma cells were exposed for 5 hours to test material at concentrations ranging from 0.065 to 1.04 µl/ml with and without metabolic activation from Aroclor-induced rat liver S-9 homogenate mixture. After exposure to the test material, the cells were allowed to recover for 3 days and then cultures were selected for cloning and mutant selection. Surviving cell populations were determined by plating diluted aliquots in non-selective growth medium. A mutation index was derived by dividing the number of clones formed in the BUdR-containing selection medium by the number found in the same medium without BUdR. The ratio was then compared to that obtained from other dose levels and negative control values. Positive control compounds were ethyl methane sulfonate (EMS) for non-activated cultures and dimethylnitrosamine (DMN) for metabolically activated cultures.

Little toxicity was observed with the test material. All results for gasoline from the non-activation assay were negative. The results from the activation assay were also considered to be negative. There was an increase in the number of mutants at the 0.52 µl/ml concentration but this appeared to result from a slight increase in the number of viable clones. There was no trend indicating a dose-related response and therefore, the increases were not believed to be compound related. Gasoline was not mutagenic in this mammalian cell system. (API, 1977a)

Gasoline tested in an Unscheduled DNA synthesis assay in rat hepatocytes with and without metabolic activation, did not cause DNA damage requiring repair in this assay system. (API 1988b) This study is not part of the SIDS data set and is not described in Robust Summaries.

Conclusion: Results from representative samples from each of the PONA categories indicate that most gasoline blending streams are not mutagenic in mammalian cells except for those substances with fairly high aromatic content where equivocal or in one case positive activity was

seen with metabolic activation. Gasoline tested in both bacterial and mammalian cell assays did not induce mutation in either test system. The read-across conclusion is that all streams in this category are negative with and without metabolic activation with the exception of streams with aromatic content greater than 60% that can be classified as negative/equivocal without metabolic activation and equivocal/positive with metabolic activation.

7.1.4. Genetic Toxicity *In Vivo*

Light alkylate naphtha (approx. 100% paraffinic) was tested in a Sprague Dawley rat chromosome aberration assay [15/sex/group] at doses of 0.3, 1.0, and 3.0g/kg in corn oil, administered intraperitoneally in a single dose. Two to four hours prior to sacrifice the rats were given a single intraperitoneal dose of colchicine (1 mg/kg). Animals [5/sex/group/time] were sacrificed at 6, 24 and 48 hrs post dose. A group of 5 animals of each sex to be used as positive controls was dosed with triethylenemelamine (TEM) at a level of 0.5 mg/kg and these animals were killed at 24 hours postdose. Deaths occurred in both male [5/18] and females [4/18] in the highest dose group and a 9-10% body weight loss was observed in surviving rats of both sexes. Other signs of toxicity included piloerection, crusty eyes and noses and excess lacrimation. Bone marrow was harvested from the femurs of treated rats, processed and stained for cytogenetic examination [a minimum of 50 metaphase spreads per animal]. No chromosome aberrations, rearrangements, or cell cycle disruption were observed in any dose group (API, 1985h**).**

Samples of light catalytic cracked naphtha (approx. 46% olefinic) were tested in two rat chromosome assays [intraperitoneal and inhalation] and in an *in vivo* mouse sister chromatid exchange (SCE) assay. LCCN (API 81-04) was tested in a Sprague Dawley rat chromosome aberration assay [15/sex/group] at doses of 0.3, 1.0, and 3.0g/kg in corn oil, administered intraperitoneally in a single dose. Two to four hours prior to sacrifice the rats were given a single intraperitoneal dose of colchicine (1 mg/kg). Animals [5/sex/group/time] were sacrificed at 6, 24 and 48 hrs post dose. A group of 5 animals of each sex to be used as positive controls was dosed with triethylenemelamine (TEM) at a level of 0.5 mg/kg and these animals were killed at 24 hours postdose. Bone marrow was harvested from the femurs of treated rats, processed and stained for cytogenetic examination [a minimum of 50 metaphase spreads per animal]. There was a 9% weight loss in males 48 hours after receiving 3 g/kg API 81-04 and a 2% weight loss in females at the same time and dose level. Clinical signs of toxicity in the 3g/kg group included lethargy in both sexes and increased tearing as indicated by a crusty appearance of fur around the eyes of the male animals. No chromosome aberrations, rearrangements, or cell cycle disruption were observed in any dose group (API, 1985i**).**

In a separate study in which exposure was by inhalation at 63, 297 and 2046 ppm, 6hr/day for 5 days, there was no evidence that light catalytic cracked naphtha (API 81-03) caused chromosomal aberrations in rats. (API, 1985c)

LCCN (API 81-03) was tested in a mouse [B6C3F1; 5/sex/group] sister chromatid exchange (SCE) assay [a non-SIDS endpoint] at doses of 0.2, 1.2, and 2.4 g/kg in corn oil, administered intraperitoneally in a single dose. Four hours prior to administration of test material, the mice were anesthetized with Metofane and an agar-coated 50mg BrdU pellet was implanted subcutaneously in the lower abdominal region. The positive control (cyclophosphamide) was injected ip at a dose level of 10 mg/kg. A second positive control (API 81-15, catalytic cracked clarified oil) was administered at a dose of 4 g/kg, which was administered by ip injection at a

rate of 10 ml/kg. Colchicine, used to arrest dividing cells in metaphase, was administered ip at 1 mg/kg to all mice two to four hours prior to sacrifice. 24 to 26 hours after BrdU pellet implantation the mice were sacrificed. Marrow was collected from both femurs. After washing and fixing bone marrow cells slides were prepared for subsequent staining and examination. Two to five slides were prepared from each animal. A minimum of 50 second-division metaphase spreads from each animal were examined and scored for SCEs and chromosome number. The mitotic index was recorded as the percentage number of cells in mitosis based upon 500 cells counted. The percentage of first, second and third-division metaphase cells was also recorded as the number per 100 cells counted. There was a significant increase in SCEs/cell when analyzed by sex. Pairwise comparisons by sex of each treatment group with its vehicle control were significantly different. (API, 1988c)

Although the SCE assay demonstrated interaction of LCCN and DNA, it was not considered definitive for clastogenic activity since no genetic material was unbalanced or lost. SCE can be regarded as more a biomarker of exposure rather than as indicator of mutagenic effect. Negative results in two assays, which visualize actual cytogenetic damage demonstrate that LCCN is not a clastogenic material (API, 1985i,c)

Sweetened naphtha (CAS # 64741-87-3, approx. 21% naphthenic; API 81-08) was tested in an inhalation rat chromosome aberration assay. Groups of 10 male and 10 female Sprague Dawley rats were exposed (whole body) to nominal concentrations of 0, 65, 300 and 2050 ppm of test material, 6 hours/day for 5 consecutive days. A positive control group of 10 rats/sex was given a single dose (0.8 mg/kg) of triethylenemelamine (TEM) intraperitoneally 24 hours before sacrifice. For the treated and negative control groups, bone marrow was harvested 6 hours after the final exposure. For the positive control group the bone marrow was harvested 24 hours after administration of TEM. Three hours prior to sacrifice by carbon monoxide the rats were given a single intraperitoneal dose of colchicine (4mg/kg). Bone marrow was collected from the tibiae of each rat and slides prepared for cytogenetic examination. Routinely 50 metaphase chromosome spreads were examined for each animal. The locations of cells bearing aberrations were identified. A mitotic index based on at least 500 cells counted was calculated by scoring the number of cells in mitosis per 500 cells on each slide read. Slides were scored for chromosomal aberrations.

No systemic toxicity was observed in this study. There was no evidence of a clastogenic effect of the test material and no significant increase in chromosomal aberration in the sweetened naphtha exposed animals when compared to the negative controls. (API, 1986h)

Three samples of catalytic reformed naphthas have been tested in a Sprague Dawley rat chromosome assay. The results for API 83-05, a full range catalytic reformed naphtha (FR-CRN, 63% aromatics) are described here. Other samples were light catalytic reformed naphtha (LCRN, 42% aromatics) and heavy catalytic reformed naphtha (HCRN, 90% aromatics). (API 1985j, k, l, respectively)

Sprague Dawley rats [15/sex/group] were given doses of 0.26, 0.82, and 2.42g/kg FR-CRN in corn oil, administered intraperitoneally in a single dose. Two to four hours prior to sacrifice the rats were given a single intraperitoneal dose of colchicine (1 mg/kg). Animals [5/sex/group/time] were sacrificed at 6, 24 and 48 hrs post dose. A group of 5 animals of each sex to be used as positive controls was dosed with triethylenemelamine (TEM) at a level of 0.5 mg/kg and these animals were killed at 24 hours postdose. One male each died in the 2.42g/kg and the 0.82g/kg groups, immediately after dosing. Toxic signs included lethargy and a moribund appearance at

the high dose and slow uncoordinated movement in the mid dose group. Bone marrow was harvested from the femurs of treated rats, processed and stained for cytogenetic examination [a minimum of 50 metaphase spreads per animal].

No chromosome aberrations, rearrangements, or cell cycle disruption were observed in any dose group. Similar cytogenetic assays have been reported for two other aromatic naphtha samples, light catalytic reformed naphtha (LCRN, 42% aromatics) and heavy catalytic reformed naphtha (HCRN, 90% aromatics) and both have given negative results. Samples in the high aromatics class do not induce chromosome damage in laboratory animals.

Gasoline

Unleaded Gasoline has been tested for induction of chromosome aberrations in rat bone marrow cells, and for transmittable genetic effects in the mouse dominant lethal assay. In the rat chromosome assay, animals were given a single intraperitoneal dose of 18.5, 62.0, and 185mg/rat (0.024, 0.08 and 0.24ml/rat) diluted in acetone, 15 rats/group, (API, 1977a) or one dose each day for 5 days at concentrations of 7.7, 23.1, and 77mg/rat (0.01, 0.03, and 0.10ml/rat/day), 18 rats total [5/treated group, 3 for acetone control] (API, 1977b). Doses were not calculated in relation to body weight. Two hours prior to sacrifice the rats were given a single intraperitoneal dose of colchicine (1mg/kg). Animals [5/sex/group/time in the acute group] were sacrificed at 6, 24 and 48 hrs post dose. For the repeat treatment study, all rats were killed 6 hours after the last dose. A group of 5 animals of each sex to be used as positive controls was dosed with triethylenemelamine (TEM) at a level of 0.3 mg/kg and these animals were killed at 24 hours postdose. Bone marrow was harvested from the femurs of treated rats, processed and stained for cytogenetic examination [a minimum of 50 metaphase spreads per animal]. The results of both studies were negative. Gasoline did not induce chromosome aberrations or disruption of cell cycle kinetics in either dosage regime.

In the dominant lethal assay, gasoline was administered by inhalation to male mice (10/group) at concentrations of 400 and 1600ppm (1493 and 5970mg/m^3), 6hr/day, 5 days/wk for 8 weeks over the entire mouse spermatogenic cycle (API 1980b). On the final day of exposure a positive control group of 10 male mice were given 0.3mg/kg triethylenemelamine (TEM) dissolved in 0.9% saline as a single intraperitoneal dose. Chamber concentrations were monitored at least hourly during the exposure periods. After 2 days rest following termination of exposures each male was caged with 2 unexposed virgin female mice. At the end of 5 days, the females were removed. This weekly mating sequence was continued for 2 weeks. Each pair of mated females was transferred to a fresh cage and after 14 days after the midweek of being caged with the male was sacrificed (approximately 2/3 through pregnancy). The uterine contents of the females were examined and scored for the numbers of dead and living implants and total implants. Gasoline exposure of male mice did not cause any significant reduction in the fertility index, did not affect the number of total implants or number of dead implants per pregnant female.

Baseline Gasoline vapor condensate [BGVC], a 20 % light fraction of a whole unleaded gasoline was tested in the rat micronucleus assay according to US EPA OPPTS 870.5395 as a satellite study to the 13 week inhalation study described in Section 7.1.2 Repeated Dose Toxicity. Sprague Dawley rats (5/sex/group) were exposed by whole body inhalation to target concentrations of 0, 2000, 10000, 20000mg/m^3 (actual concentrations 0, 2050, 10,153 and 20,324 mg/m^3) BGVC for 4 weeks, 6hr/day, 5 days/week. A separate positive control group was treated with 40mg/kg cyclophosphamide by intraperitoneal injection 24 hours prior to sacrifice. Rats were killed 24 hours after the 20^{th} exposure and bone marrow from both femurs of each rat was prepared as smears on microscope slides. Slides were stained by the modified Feulgen method. One smear from each rat was examined for the presence of micronuclei in 2000

immature erythrocytes and cytotoxicity was determined by the ratio of immature erythrocytes in at least 1000 erythrocytes. The incidence of micronucleated mature erythrocytes was also recorded. BGVC did not cause statistically significant increases in micronucleated immature erythrocytes or micronucleated mature erythrocytes at any dose level. There was no cytotoxicity or a decrease in the proportion of immature erythrocytes observed. Baseline Gasoline Vapor Condensate did not induce cytogenetic damage in this test system. NOAEL = 20324mg/m^3. (API, BGVC, 2005b)

BGVC was also tested with a separate satellite group for the induction of sister chromatid exchange [SCE- a non-SIDs endpoint], using an in vivo/in vitro protocol. Sprague Dawley rats (5/sex/group) were exposed by whole body inhalation to target concentrations of 0, 2000, 10000, 20000mg/m^3 (actual concentrations 0, 2050, 10,153 and 20,324 mg/m^3) BGVC for 4 weeks, 6hr/day, 5 days/week. A separate positive control group was treated with 5mg/kg cyclophosphamde by intraperitoneal injection 24 hours prior to sacrifice. Rats were killed 24 hours after the 20th exposure. Blood (2-4ml) was collected from the abdominal aorta, cultured within 24 hours and incubated at 37^{0}C for 21 hours. Cells were then exposed to 5µg/ml bromodeoxyuridine. After 68 hours from culture initiation, 0.2µg/ml colcimid was added to each culture flask to arrest cell division and incubation continued for 4 hours. At 72 hours total elapsed culture time, cells were collected, washed and fixed. Slides were prepared for microscopic evaluation. A minimum of 25 second-division metaphases per animal was scored for SCE. At least 100 consecutive metaphases per animal were scored for the number of cells in 1st, 2nd, and 3rd division metaphases as an indicator of toxicity (cell cycle delay) and 1000 cells were scored for mitotic index per rat. Statistically significantly increased SCE frequency was observed at all 3 dose levels in females and at the 10153 and 20324mg/m^3 levels for males. Increases in average generation time were also observed but no appreciable differences in mitotic indices were seen for any test group compared to controls. Although the SCE assay demonstrated interaction of BGVC and DNA, it was not considered definitive for clastogenic activity since no genetic material was unbalanced or lost, but rather a biomarker of exposure. Negative results in a parallel micronucleus assay, which visualizes actual cytogenetic damage demonstrate that BGVC is not a clastogenic material (API, BGVC, 2005c)

Conclusion: All PONA streams are negative for induction of chromosome aberrations in rats. One high olefinic sample induced sister chromatid exchanges in mice. Although the SCE assay demonstrated interaction of the LCCN sample and DNA, it was not considered definitive for clastogenic activity since no genetic material was unbalanced or lost, but rather a biomarker of exposure. Negative results in two assays in rats, which monitor actual cytogenetic damage demonstrated that LCCN was not a clastogenic material. Gasoline did not induce cytogenetic damage in rats or adverse effects on spermatogenic cycle in mice. Although SCEs were induced in cultured peripheral blood from rats exposed to baseline gasoline vapor concentrate, the parallel micronucleus study was negative. Overall gasoline refinery blending streams are not clastogenic. The read-across conclusion for untested streams in this category is negative for in vivo genetic toxicity.

7.1.4 Reproductive and Developmental Toxicity

Light alkylate naphtha (CAS #64741-66-8, LAN, approx. 100% paraffinic) was tested in rats in an OECD 421 Inhalation Reproductive and Developmental Toxicity Screening Test as a light

end distillate. The test material (LAN-D) was prepared to be representative of the fraction of light alkylate naphtha to which humans would normally be exposed during normal handling and use. It was obtained by the distillation of LAN and collecting that fraction that boiled over the temperature range 78 to 145°F. Male and female Sprague Dawley rats (12/sex/group) were exposed to concentrations of 0, 137, 3425 and 6850ppm, 6 hours/day, 7 days/week for 2 weeks prior to mating. The maximum exposure level was 75% of the lower explosive limit for LAN distillate. Parental males were also exposed during mating, throughout the female gestation and post partum period and throughout the female necropsy period (8 consecutive weeks). During the mating period, females were exposed until evidence of mating was observed. If there was no evidence that mating had occurred the pairs were allowed to remain together up to a period of 2 weeks after which time the female was assumed to be pregnant. Presumed pregnant females were treated daily during gestation (GD days 0-19) until sacrificed on post-natal day 4. Parental females were killed on gestation day 25 if they had not delivered. Viability, clinical observations, body weights, feed consumption, and survival were evaluated in parental rats. At necropsy each parental animal was examined macroscopically for structural abnormalities and pathological changes with emphasis on reproductive organs. Lungs, trachea and larynx were removed in their entirety. The right middle lobe of the lung was weighed; the remaining lobes were fixed for subsequent histopathological examination. The testes and epididymides of the males were weighed and then fixed for histological examination, as were the ovaries of the females. Reproductive parameters (mating indices, pregnancy rates, male fertility indices, gestation length, number of implantation sites and corpora lutea, pre- and post-implantation loss, pups per litter, live born and stillborn pups, and incidence of dams with no viable pups) and developmental endpoints (pup physical examination, viability, weight, sex ratio, litter survival indices and mean pup survival indices) were evaluated.

No adverse reproductive or systemic effects were induced in treated male and female rats. All pregnant females had comparable delivery data and pups in all groups showed comparable birth weights, weight gain, and viability at postnatal day 4. No histopathological changes were seen at necropsy for adults or offspring, and reproductive organs of adult animals were normal histologically. NOAEL for all endpoints = 6850ppm [25000mg/m^3], the highest dose tested (Bui et al., 1998).

Light catalytic cracked naphtha (CAS #64741-55-5, LCCN, approx. 42% olefinic) was tested in rats in an OECD 421 Inhalation Reproductive and Developmental Toxicity Screening Test as a light end distillate (approx. 60% olefinic). Male and female Sprague Dawley rats (10/sex/group) were exposed to concentrations of 0, 750, 2500 and 7500pppm (2700, 9000 and 27000mg/m^3), 6 hours/day, 7 days/week for 2 weeks prior to mating. The maximum exposure level was 75% of the lower explosive limit for LCCN distillate. Parental males and females who failed to mate were exposed during mating, and 23 additional days following completion of the mating period. These animals were sacrificed shortly after the last litters were delivered reached post partum day 4. During the mating period, females were exposed until evidence of mating was observed. If there was no evidence that mating had occurred the pairs were allowed to remain together up to a period of 2 weeks. Pregnant females were treated daily during gestation (GD days 0-19) until sacrificed on post-natal day 4. Viability, clinical observations, body weights, feed consumption, and survival were evaluated in parental rats. At necropsy each parental animal was examined macroscopically for structural abnormalities and pathological changes with emphasis on reproductive organs. The following organs were weighed and organ/body weight ratios were calculated: adrenals, brain, heart, kidneys, liver, lung, spleen, epididymides, testes and thymus. Twenty-seven tissues were preserved from all adult animals in all dose groups. Ovaries, testes, epididymides, nose with nasal turbinates, and any grossly

observed abnormalities were processed and sections examined histologically for all males and female parental animals in the control and highest dose group. Reproductive parameters (mating indices, pregnancy rates, male fertility indices, gestation length, number of implantation sites and corpora lutea, pre- and post-implantation loss, pups per litter, live born and stillborn pups, and incidence of dams with no viable pups) and developmental endpoints (pup physical examination, viability, weight, sex ratio, litter survival indices and mean pup survival indices) were evaluated. Pups were sacrificed on day 4 of lactation and underwent a complete macroscopic examination and a determination of sex by internal examination. All pups were preserved with viscera intact. Pups found dead at birth and that died prior to day 4 of lactation also underwent a gross external and internal examination. Dead pups were not eviscerated, but were preserved intact.

All groups had a fertility index of >90% and a live birth index greater than or equal to 98%. Offspring showed comparable body weights, weight gain, and viability index at postnatal day 4. Parental male rats had increased kidney weights and relative liver weights at the highest dose, and high dose females had increased spleen weights. Reproductive organs and nasal turbinates from high dose and control animals were examined by a pathologist and no histological changes were observed in tissue from treated rats. LOAEL parental toxicity = 7500ppm [27000mg/m^3] NOAEL parental toxicity = 2500ppm [9000mg/m^3]; NOAEL reproductive performance/ developmental toxicity = 7500ppm [27000mg/m^3] (Schreiner et al., 1999).

An Inhalation Developmental toxicity screening study in Sprague Dawley rats [10/sex/group] and CD-1 mice [15 presumed pregnant females/group] exposed to a 40% vapor of LCCN at concentrations of 0 [untreated controls], 0 [sham-treated controls], 597, 2128ppm [2150 & 7660 mg/m^3], 6 hours/day, for gestation days 0-19. The vapor contained approximately 41% olefins. All animals were observed daily and body weights were recorded on days 0, 6, 13 and 20 of gestation. On day 20 each female was sacrificed and all organs were examined grossly. Serum samples were analyzed for a variety of parameters, including serum iron and lactic dehydrogenase. The number of corpora lutea per ovary and the gravid uterine weights were recorded. Uterine contents were examined and the numbers of implantation sites, early resorptions and live and dead fetuses recorded. Each fetus was identified for its sex, was weighed and the crown-rump distance was measured. Each fetus was examined for external anomalies. Half the fetuses were fixed in Bouin's solution and examined for visceral anomalies and the remaining fetuses were prepared for examination for skeletal anomalies.

There were no treatment related clinical abnormalities or differences in body weights among dams or adverse effects on reproductive parameters with the exception of a statistically significant increase in resorptions and percent resorptions at the 2128ppm dose [10.4% vs 4.6% in untreated controls and 3.9% in sham controls] and an increased incidence of high dose dams with resorptions compared to sham but not to untreated controls. The authors considered the biological significance of the increase in resorptions to be uncertain because the number of viable fetuses (i.e. litter size) in this group were comparable to litter size in other groups and the mean incidence of resorptions in the control groups from previous studies at this facility ranged from 3.0 to 11.2% compared to the 10.4% in the 2128ppm group. No visceral abnormalities were observed. There were an increased number of skeletal variations in animals housed in the exposure chambers (exposed and sham treated controls) when compared to the untreated controls. The authors concluded that these alterations were not related to LCCN since they occurred at a similar incidence in the sham treated controls as well. Despite the reservations of the authors, the developmental LOAEL is identified as 2128ppm (7660 mg/m^3) based on increased resorptions and NOAEL = 597ppm (2150mg/m^3) (Dalbey et al., 1996)

Two additional studies on LCCN, a single dose oral developmental study and a dermal developmental study are described in the Supplemental studies section below.

Heavy straight run naphtha (HNN, CAS # 64741-41-9, approximately 30% naphthenic) was tested by inhalation in an OECD 422 Combined Repeated Dose Toxicity Study with the Reproductive/Developmental Toxicity Screening Test. This was the same study described in greater detail in the systemic repeated dose section (Section 7.1.2.3). Concentrations of HNN were generated by flash evaporation of the test material. Groups of male and female Sprague Dawley rats [12/sex/group] were exposed to 0, 100, 500 or 3000ppm [0, 459, 2296, or 13773mg/m^3] for approximately 28 days. Satellite groups of 12 young, nulliparous, non-pregnant female rats were exposed to 0, 100, 500, or 3000 ppm during a premating period of approximately 2 weeks, a cohabitation period of approximately 2 weeks, and a gestation period of approximately 3 weeks. The animals were not exposed after gestation day 19, or during the approximately 4-day lactation period. Females without evidence of mating continued to be exposed for 19 days after the end of the cohabitation period. Measurements of body weight, food consumption, and clinical signs of toxicity in females were conducted throughout premating, cohabitation, gestation, and lactation. On postpartum day 4, blood samples were collected from lactating females for haematology and clinical chemistry parameters. In addition, the neurobehavioral evaluation was conducted on lactating females on postpartum day 4, and subsequently, lactating females and offspring were sacrificed, and organs [liver, kidney, lungs, ovaries with oviducts, and uterus with cervix) were weighed. Microscopic evaluation was performed on reproductive organs from females that failed to produce a litter. Offspring were evaluated for external abnormalities. Reproductive parameters (mating indices, pregnancy rates, gestation length, fertility index, pre-coital interval, number of implantation sites and corpora lutea, post-implantation loss, pups per litter, live born and stillborn pups, and incidence of dams with no viable pups) and developmental endpoints (pup physical examination, viability, weight, sex ratio, litter survival indices and mean pup survival indices) were evaluated.

Test substance related effects on body weight and weight gain were observed in 3000ppm females during the three-week gestation period. Body weight on GD21 was 7% lower than controls and the weight gain from GD0-21 was 14% lower than controls and was considered an adverse effect. The statistically significantly lower maternal body weight in 3000ppm dams at LD0 correlated with the lower weight trend in high dose females during gestation. The overall weight gain from LD0-4 was comparable to controls although the 3000ppm female body weight did not fully return to control values but was not statistically significantly lower. Only one mating pair in the 3000ppm group failed to produce a litter, resulting in a mating index of 92% in that group and 100% in all other groups. There were no test substance-related or statistically significant differences in mean number of pregnant animals, number of animals delivering, mating index, fertility index, precoital interval, gestation length, number of corpora lutea, number of implantation sites, or percent of post-implantation loss for any exposure concentration. There were no test substance-related or statistically significant differences in number of fetuses born or born alive, live born index, viability index, sex ratio, incidence of clinical observations, or mean fetal body weight on postnatal days 0 or 4. There were no HNN related effects on neurobehavioral, clinical chemistry or haematology parameters for lactating females.

The NOAEL for developmental and reproductive endpoints and neurobehavioral endpoints for LD4 dams = 3000ppm (13650mg/m^3), the highest dose tested. Systemic toxicity values for all adult animals were LOAEL = 3000ppm (13650mg/m^3) and NOAEL = 500ppm (2275mg/m^3) (API, 2008a)

Light catalytic reformed naphtha (CAS #64741-63-5, LCRN, 33% aromatic) was tested in rats in an OECD 421 Inhalation Reproductive and Developmental Toxicity Screening Test as a light end distillate. The test material (LCRN-D) was prepared to be representative of the fraction of light catalytic reformed naphtha to which man might be exposed during handling and blending. Male and female Sprague Dawley rats (10/sex/group) were exposed to concentrations of 0, 250, and 7500pppm (2775, 9250 and 27750mg/m^3), 6 hours/day, 7 days/week for 2 weeks prior to mating. The maximum exposure level was 75% of the lower explosive limit for LAN distillate. Parental males and females that subsequently failed to mate were exposed during mating, and an additional 18 days following completion of the mating period. Males were killed shortly after the last litters reached day 4 of lactation. During the mating period, females were exposed until evidence of mating was observed. If there was no evidence that mating had occurred the pairs were allowed to remain together up to a period of 2 weeks. Presumed pregnant females were treated daily during gestation (GD days 0-19) until sacrificed on post-natal day 4. Viability, clinical observations, body weights, feed consumption, and survival were evaluated in parental rats. Unmated females or those who failed to produce a litter were killed 23 days after completion of the mating period. At necropsy each parental animal was examined macroscopically for structural abnormalities and pathological changes with emphasis on reproductive organs. Lungs, trachea and larynx were removed in their entirety. The right middle lobe of the lung was weighed; the remaining lobes were fixed for subsequent histopathological examination. The testes and epididymides of the males and the ovaries of the females were weighed and then fixed for histological examination. Reproductive parameters (mating indices, pregnancy rates, male fertility indices, gestation length, number of implantation sites and corpora lutea, pre- and post-implantation loss, pups per litter, live born and stillborn pups, and incidence of dams with no viable pups) and developmental endpoints (pup physical examination, viability, weight, sex ratio, litter survival indices and mean pup survival indices) were evaluated.

All parental animals survived to scheduled sacrifice and no treatment related clinical signs were observed. Except for a slight reduction in body weights in the high dose males there were no other effects on either body weight or food consumption. The only treatment related organ weight changes were an increase in relative kidney (15%) and relative liver (5%) weights in the high dose males. No other organ weight changes were recorded. There were no treatment-related microscopic changes in the testes, epididymides, ovaries or nasal turbinates in the animals in the high dose group.

All groups had a mating index and a fertility index of 100% and all animals in all groups had mated within 4 days of cohabitation. Delivery and litter data did not demonstrate any effects of treatment. External and internal examination of pups sacrificed on day 4 of lactation resulted in only one pup in a single litter of the control group with abnormalities.

Parental toxicity LOAEL = 7500ppm (27750 mg/m^3) based on slightly decreased body weight and increased relative liver weight; NOAEL parental toxicity = 2500ppm (9250 mg/m^3). NOAEL for reproductive performance/ developmental toxicity = 7500ppm (27750mg/m^3) (Schreiner et al., 2000).

Full range catalytic reformed naphtha (CAS # 68955-35-1, FR-CRN, >60% aromatics) was tested as a 40% vapor in a developmental toxicity study in rats. Groups of 11 or 12 presumed pregnant female rats were exposed 6 hours each day from days 6-19 of gestation to 0, 508, and 1835ppm (0, 2160 and 7800mg/m^3) partially vaporized FR-CRN. Two extra groups served as untreated and sham treated controls. All animals were observed daily and body weights were recorded on days 0, 6, 13 and 20 of gestation. On day 20 each female was sacrificed and blood

samples removed for serum chemistry evaluations that included iron and lactic dehydrogenase. All maternal organs were examined grossly and liver and thymus weights were recorded. In addition, the number of corpora lutea per ovary and the gravid uterine weights were recorded. Uterine contents were examined and the numbers of implantation sites, early and late resorptions and live and dead fetuses were recorded. Each fetus was gendered, weighed and grossly examined for external abnormalities. Half the fetuses were fixed in Bouin's fluid and examined subsequently for soft tissue abnormalities. Remaining fetuses were stained with Alizarin red and examined for skeletal anomalies.

There were no adverse effects on maternal body weight gain, liver weight or thymus weight. In the high dose group, maternal serum glucose levels were slightly decreased (1.5%) and potassium levels slightly increased (1%) relative to the untreated controls. Reproductive performance during gestation and in-utero survival and development of concepti were unaffected by treatment. There were no treatment-related increases in gross abnormalities or anomalies of soft or skeletal tissues.

The NOAEL for maternal and developmental endpoints = 1835ppm (7800mg/m^3) (Dalbey and Feuston, 1996)

Results for both distillate and vapor studies were similar. No treatment related reproductive or developmental effects were reported for these aromatic samples. A dermal developmental toxicity study with a full range coker naptha is described in the Supplemental studies section.

Supplemental studies

Light catalytic cracked naphtha (LCCN, CAS # 64741-55-5) was tested in a dermal developmental toxicity study. LCCN was applied to the clipped backs of pregnant Sprague Dawley rats (10/group) at concentrations of 0, 30, 125, or 500mg/kg/day from GD0-19. An additional group contained pregnant animals treated with 500mg/kg/day LCCN from GD0-18, following which a one-day dermal dose of LCCN+^{14}C-octane and ^{3}H-benzo(a)pyrene was administered on GD19 to monitor bioavailability. Placental and fetal samples and maternal blood were combusted and radiolabel content in the residue was measured by liquid scintillation counting.

Slight to moderate skin irritation was observed at the application site at all dose levels. Maternal parameters [body weight and weight gain and food consumption] and serum chemistry parameters were comparable to controls. No treatment related effects were seen on reproductive endpoints [number of corpora lutea, implantation sites, resorptions, live and dead fetuses], fetal viability, fetal body weights or crown-rump length. No teratogenic findings were seen in soft tissue or skeletal evaluations. Up to 0.12% ^{14}C radioactivity and 1.3% ^{3}H radioactivity were identified in maternal blood, placenta and fetal tissue at study termination, demonstrating that LCCN passed the maternal barrier into the fetal system but did not induce adverse effects. The developmental NOEL was greater than 500mg/kg, the highest dose tested. (Mobil, 1988b)

In another study, a 2000mg/kg single oral dose of LCCN was administered to pregnant Sprague Dawley rats on Day 13 of gestation. This material was tested with a series of other refinery streams to identify and compare any potential direct teratogenic effects that might be obscured by maternal or fetal toxicity resulting from repetitive exposure. Clinical signs of moderate to severe toxicity were seen in the first rats treated with LCCN to the extent that, although no females died, fetal viability may have been compromised; the test group was thus limited to 5 animals. Caesarean sections were performed on GD20. Body weight and weight gain were significantly reduced following exposure but effects were transient and normal weight gain

resumed for the remainder of the study. No adverse effects on reproductive parameters [number of corpora lutea, implantation sites, resorptions, live and dead fetuses] were observed and no teratogenic events in soft tissue or skeletal specimens were seen. LCCN was not a developmental toxicant in this system. (Stonybrook Laboratories, 1995i)

Full range coker naptha (CAS # 68513-02-0; ARCO F-250 Merox Feed) was tested in a dermal developmental toxicity study with pregnant Sprague Dawley rats. The undiluted test material was applied daily to the shaved backs to 12 rats/ treated group at concentrations 0 (15 control rats), 100, 500 and 1000mg/kg from GD0-20. Test sites were not occluded. Animals were allowed to deliver litters and nurse pups through lactation day 4. Irritation at the test application site was observed in maternal animals at all dose levels. There were no statistically significant differences in reproductive parameters [number of females delivering live litters, gestation length, number of implantation sites, number of litters with live pups] or offspring survival at lactation days 0 or 4, pup sex ratio or pup body weight. The NOEL for developmental toxicity was 1000mg/kg, the highest dose tested. (ARCO, 1994)

Gasoline

Unleaded gasoline and gasoline vapor have been tested for developmental and reproductive effects. Pregnant Sprague Dawley rats were exposed by inhalation to unleaded gasoline vapor at concentrations of 0, 400 and 1600ppm (0, 1493, and 5970mg/m^3) from day 6-15 of gestation; caesarean sections were performed on day 20 Mated females were weighed on days 0, 6, 15 and 20 of gestation. Food consumption was recorded daily during the periods 0-6, 6-15 and 15-20 days of gestation. Observations were made daily for clinical signs. On day 20 of gestation the female rats were anesthetized and their visceral and thoracic organs were examined. The uterus was removed and opened and the number of implantation sites, their placement in the uterine horns, live and dead fetuses and resorption sites recorded. The fetuses were removed, examined externally for abnormalities and weighed. One third of the fetuses from each litter were fixed in Bouin's solution and examined later for changes in the soft tissues of the head, thoracic and visceral organs. The remaining fetuses in each litter were stained with Alizarin Red S and examined for skeletal abnormalities.

There were no treatment-related effects on body weight or food consumption. There were no treatment related effects on any reproductive parameter (pregnancy ratio, live litters, implantation sites, litters with resorptions, dead fetuses, litter size, fetal weights), or fetal soft tissue or skeletal examination. NOEL for maternal and developmental toxicity = 1600ppm (5970mg/m^3). (API, 1978)

An unleaded gasoline vapor condensate (10.4% by volume of starting gasoline) was also evaluated for developmental toxicity in pregnant Sprague Dawley rats by inhalation at target concentrations of 0, 1000, 3000, and 9000ppm (0, 2653, 7960, and 23900mg/m^3) [actual concentrations 0, 1015, 2984, 8993ppm; 0, 2693, 7918, 23881mg/m^3] from day 6-19 of gestation according to US EPA TSCA test guideline 798-4350. No maternal toxicity was observed. At caesarean section on day 20 of gestation, no treatment related effects were identified for any reproductive parameter (pregnancy ratio, live litters, implantation sites, litters with resorptions, dead fetuses, litter size, fetal weights) or fetal malformations or variations. The NOAEL for maternal and developmental toxicity = 8993ppm; [23881mg/m^3]. (Roberts et al, 2001)

A developmental toxicity study in rats of Baseline Gasoline Vapor Condensate (BGVC), a 20% light fraction of whole unleaded gasoline was performed according to OPPTS 870.3600,

870.3700 and OECD 414 guidelines. This test material was a representative evaporative emission tested under the US EPA 211(b) Fuels and Fuel Additives Health Effects Testing Program (1994b). BVCG was administered to confirmed pregnant Sprague Dawley rats (25/group) at target concentrations of 0, 2000, 10000, and 20000mg/m^3 (analytical concentrations 0, 1979, 10,676 and 20,638mg/m^3) 6hr/day, from Gestation Day 5 through Gestation Day 20 the period of major organogenesis and fetal growth. There was no evidence of maternal toxicity. At caesarean section on day 21 of gestation, there were no statistically or biologically significant differences for uterine implantation data, and external, visceral, and skeletal observations in the fetuses. Statistically significant reduced mean fetal body weights were noted for all treatment groups. There was no dose response pattern in these decreased weights. However, the fetal body weights of the treated groups were within the historical control range of the laboratory while the mean fetal body weights of both sexes of the control group were greater than the historical range. Additionally, the litter weights and the weights of the male and female components of the litter weights did not correlate with this decrease. Therefore, the decreased fetal body weights while statistically significant were not considered biologically significant. The NOAEL for maternal and developmental toxicity = 20,638 mg/m^3. (API, BGVC, 2008b)

Reproductive toxicity was evaluated in a 2-generation inhalation study with Baseline Gasoline Vapor Condensate (BGVC), a 20% light fraction of whole unleaded gasoline according to OPPTS 870.3800. This test material was a representative evaporative emission tested under the US EPA 211(b) Fuels and Fuel Additives Health Effects Testing Program (1994b). BVCG was administered to Sprague Dawley rats (26/sex/group) at target concentrations of 0, 2000, 10000, and 20000mg/m^3 (actual concentrations 0, 2014, 10,319 and 20,004 mg/m^3) 6hr/day, 7 days/week for 10 weeks before mating and 2 weeks of mating. Exposure of parental females [P0] with confirmed matings was continued until Gestation Day [GD] 19 and suspended until postpartum day 5 to avoid inducing undue stress to the dams during birth and early lactation. P0 dams continued to be exposed to BGVC until sacrifice at weaning. At weaning of the F1 generation on postpartum day 28, one pup/sex/litter was chosen randomly to continue exposure as the F1 parental generation; littermates were never paired together. Exposure of the F1 parental generation to BGVC began at weaning with 10 weeks of premating exposure and continued on the same schedule as the P0 parental generation through mating gestation and lactation. Physical observations, body weights and food consumption were monitored at least weekly during the study. After approximately 16 weeks of exposure, all parental males [P0 and F1] were sacrificed and all parental females [P0 and F1] were sacrificed on their respective postpartum days 28. Females that failed to mate were sacrificed 25 days after the end of the mating period. Fourteen organs were weighed from all rats and tissues from these organs were examined microscopically from 10 rats from the control and 20000mg/m3 groups. Reproductive organs from all males and bred females in the control and high dose groups were examined. Sperm evaluations included motility, counts of testicular homogenization-resistant sperm and cauda epididymal sperm, and sperm morphology in the cauda epididymis. Ovary histopathology included evaluation of primordial follicle population, number of growing follicles and corpora lutea. Pups (F1 and F2 generations) were observed as soon as possible after delivery for sex, number of live and dead pups and pup abnormalities. Pups dead at delivery were identified as stillborn or liveborn/found dead based on lung floatation evaluation. Thereafter litters were observed twice daily. On LD 4, F1 litters with more than 10 pups were randomly culled to 10 pups with sex distribution equalized if possible. Pups were examined and weighed on LD1 (delivery day), 4 (preculled), 7, 14, 21 and 28. At weaning one pup/sex/group was selected for mating to produce the F2 generation. F1 pups [5/sex/group/assessment] not selected for F1 mating were evaluated for standard Tier 2 neuropathology [40 CFR79.66] or for glial fibrillary acidic protein (GFAP) assessments [40 CFR79.67] on postpartum day 28 [Results of the GFAP study are reported in a separate Neurotoxicity robust summary but the GFAP

assay is considered beyond the scope of this document]. The remaining pups were sacrificed. Three pups/sex/litter in each group were selected for macroscopic examination and selected organs [brain, spleen, thymus] were weighed from one pup/sex/litter.

Exposure of rats to 2014, 10,319 and 20,004 mg/m^3 of vapor of test substance resulted in decreased body weight gains in the P0 females and F1 males prior to mating in the 20004 mg/m^3 exposed group. Increases in kidney weights in parental male animals exposed to the two higher exposure levels of vapor were consistent with alpha 2-microglobulin mediated nephropathy seen in these animals, a finding has been generally accepted not to be relevant to human risk assessment (US EPA, 1991). There was no effect at any of the exposure levels on reproductive performance in the study, including mating, fertility, parturition, lactation, offspring survival and development or maturation, in either the P0 or F1 generations. Pregnancy rates for control, 2014, 10,319 and 20,004 mg/m^3 groups were 96.0%, 96.2%, 92.3% and 100% respectively for P0 animals and 100%, 100%, 91.7% and 100%, respectively for F1 animals. There was no evidence of any neuropathology in F1 pups as a result of the exposures. The NOAEL for systemic toxicity [excluding kidney effects in male rats] is 10319mg/m^3. The NOAEL for neurotoxicity in F1 animals is >20,004mg/m^3. The Reproductive NOAEL is >20,004mg/m^3. These results are comparable to those seen in other gasoline studies and with the refinery streams representative of the 4 chemical classes. (API, BGVC, 2008c)

Reproductive toxicity was also evaluated in a 2-generation study with Vapor recovery gasoline Sprague Dawley rats (30/sex/group) at concentrations of 0, 1850, 3700 0r 7400ppm (0, 5000, 10000, and 20000mg/m^3) in accordance with OECD protocol 416 and US EPA OPPTS 870.3800 draft guideline for reproduction and fertility effects (1994). The test material was a condensate of gasoline vapor that had been collected from a vapor recovery unit during normal operations. This test material was selected since it was representative of the exposures that normally occur for the general public during self-service refueling. Analytical studies were conducted on the condensate and the results compared with exposure studies that had been carried out during refueling operations. The results confirmed that the vapor recovery condensate was similar in composition to the vapors to which the public is exposed during refueling.

Singly housed animals were exposed for 10 weeks prior to mating followed by a 3 week mating period. Mating was confirmed by either presence of sperm in a vaginal rinse or by the presence of a vaginal plug. Exposure of females was continued until gestation day 20 and was then suspended until post partum day 5 to avoid unduly stressing the dams during birth. Exposure was re-commenced and continued until sacrifice of parental females after weaning. The pups were culled on a random basis to approximately 5/sex/litter. At weaning on postnatal day 28, the F1 pups were selected for the second generation. Among the pups not selected, 3/sex/litter were sacrificed and examined for internal abnormalities. The remainder were examined for external abnormalities, sacrificed and discarded. Pups selected for F1 were exposed for a 13 week premating period and for a 3 week mating period as described above. The males were sacrificed at this time and the females continued to be exposed until gestation day 20. Exposures were resumed on post partum day 5 and were continued until weaning, when all remaining animals were sacrificed. Other than during the period from gestation day 20 until post partum day 5, all F1 offspring were exposed from conception to sacrifice. All animals were examined regularly for viability and clinical observations. Body weights and food intakes were also recorded regularly throughout the study. All pups were counted and examined externally on a daily basis and weighed at regular intervals until post-natal day 21. F1 pups were examined regularly between postnatal days 21 to 28 and were weighed on days 28 and 35. All surviving F1 and F2 pups were examined for developmental landmarks, including pinna

detachment, hair growth, incisor eruption, eye opening and the development of the surface-righting reflex. Surviving F1 female offspring were monitored for vaginal opening and males were examined for preputial separation. Reproductive parameters evaluated included: male and female fertility indices, male mating index, female fecundity and gestational indices, mean litter size, mean days of gestation, female estrous cycle length and number of females cycling normally. Live birth index, survival index, survival indices (post partum days 1, 4, 7, 14 and 21), viability index at weaning, mean live and dead offspring on day 0, sex ratio at day 0, offspring in-life observations, offspring body weight and offspring gross postmortem findings were also assessed. Randomly selected culled pups were necropsied and the following organs weighed: ovaries, liver, adrenals, testes, kidneys, spleen and brain. Additionally a wide range of tissues was taken for histology. Similar evaluations were also carried out on all adults surviving to scheduled sacrifice. Tissues taken from the high dose group and controls were evaluated histologically. Samples of sperm from the left distal cauda epididymis were collected from all males at terminal sacrifice for evaluation of sperm parameters. These included assessments of total caudal epididymal sperm numbers, % progressively motile sperm and homogenization resistant spermatid count, % morphologically normal sperm and % sperm with an identified abnormality. An ovarian examination was carried out in the females that included confirmation of growing follicles and corpora lutea and quantification of primordial oocytes in the high dose and control groups. Since there were no abnormal findings in the high dose group, other groups were not evaluated.

There were no treatment related systemic effects in parental females and only the species and sex specific increased hyaline droplet formation consistent with alpha 2-microglobulin mediated nephropathy was observed in kidneys of male rats of both generations. These kidney lesions have been determined not relevant to humans (EPA, 1991) and were excluded in parental NOAEL determination. No reproductive parameters were affected and there were no deleterious effects on offspring survival and growth in either generation. Sperm count and quality in both P1 and P2 (F1) males were comparable in all dose groups. NOAEL for parental and reproductive toxicity = 7400ppm (20000mg/m^3) (McKee et al, 2000).

Conclusions: Developmental or reproductive toxicity was not observed in dermal studies, or by inhalation in rats for distillate or vapor samples in any PONA class with the exception of one 40% olefinic sample [chamber vapor content 41% olefins] developmental study in which increased resorptions were reported at the highest dose [2128ppm; (7660mg/m^3)]. Of note is that the authors were not sure of the biological significance of this occurrence. The distillate sample of the same CAS number with higher olefin content [chamber vapor content 61% olefins] run at higher exposure concentrations did not show any reproductive toxicity. In addition, no developmental effects were seen with wholly vaporized gasoline [NOAEL = 1600ppm (5970mg/m^3], a 10% distillate sample of unleaded gasoline [NOAEL = 8993ppm (23881mg/m^3)], or a baseline gasoline vapor condensate [NOAEL = 20,638 mg/m^3] nor in two 2 generation study reproduction studies with vapor recovery gasoline or baseline gasoline vapor condensate [NOAEL ≥ 20,000mg/m^3in both studies]. No increases in resorptions were reported in any of these studies. Based on the absence of increased resorptions with naphthas and gasoline in other study results and the opinion of the authors themselves, it was concluded that the increase in resorptions seen in the 40% vapor sample may have been unique to that test sample and is not considered representative of refinery streams in general. This study has not been used to establish the lower limit of the read-across range. As there were no other appreciable differences between paraffinic, olefinic, naphthenic and aromatic streams, a range of values derived from all developmental and reproductive toxicity studies have been used to read-across to untested category members. NOAEL values for developmental and reproductive

effects reflect the maximum doses tested. Parental systemic LOAEL and NOAEL values over all studies reflect primarily decreases in body weights at maximum doses. The read-across ranges are:

Developmental NOAEL = 5970mg/m^3 to 27750mg/m^3,

Reproductive NOAEL = 13650 mg/m^3 to 27750 mg/m^3

Parental systemic toxicity LOAEL = 13650 mg/m^3 to 27750 mg/m^3:
NOAEL = 2275 mg/m^3 to 25000 mg/m^3

[Parental toxicity values were determined exclusive of male kidney effects indicative of alpha 2-microglobulin mediated nephropathy, also identified as light hydrocarbon induced nephropathy, a species and sex specific syndrome that does not occur in female rats or other species, including humans and is not relevant to humans (US EPA, 1991)]

7.2 Human Health Effects Other

7.2.1 Carcinogenicity

7.2.1.1 Inhalation Carcinogenesis

Gasoline

A two year inhalation carcinogenesis bioassay was performed with wholly vaporized unleaded gasoline at actual concentrations of 0, 67, 292 and 2056ppm (250, 1089, 7672mg/m^3) administered to rats and mice [100/species/sex/group]. Exposures were for 6 hours a day, 5 days each week for up to 113 weeks. All animals were individually housed and were allowed free access to food and water except during the exposure periods. All animals were observed twice daily, once before and once after the exposure period. Animals found moribund were removed from the study and sacrificed. All animals were examined once per month for clinical signs and palpable tissue masses. Body weights were recorded monthly for the first 17 months and bi-weekly thereafter. After approximately 18 and 24 months exposure blood was collected from 7 male and 7 female rats from each dose group for hematological and clinical chemistry evaluations. After 3, 6, 12 and 18 months exposure 10 rats and 10 mice of each sex from each dose group were sacrificed and underwent complete post mortem examinations. At study termination all surviving animals were sacrificed. Body weights were recorded and after gross examination a wide range of organs/tissues were removed, weighed and fixed for subsequent histopathological examination.

Mortality rates were unaffected in either species. Rats and mice in the highest dose group had lower body weights throughout the study. Hematology and clinical chemistry parameters were comparable to control for each species. Kidney weights of male rats were elevated accompanied by alpha 2 microglobulin mediated nephropathy also identified as light hydrocarbon nephropathy at interim sacrifices and dose related incidences of kidney tumor at terminal sacrifice. These kidney lesions have been determined to be species and sex specific and not relevant to humans (EPA, 1991). Rat LOAEL, excluding kidney lesions = 2056ppm (7672mg/m^3) based on decreased body weight; NOAEL = 292ppm (1089mg/m^3)

In mice, hepatocellular tumors were present in high dose females, although organ weights were unaffected. No nephropathy was present in male kidneys. Mouse LOAEL = 2056ppm (7672mg/m^3) based on decreased body weight and liver tumors in females; NOAEL = 292ppm (1089mg/m^3). (McFarland et al, 1984).

Conclusions: Excluding kidney effects in the male rat, wholly vaporized unleaded gasoline was not carcinogenic in rats or male mice. Wholly vaporized unleaded gasoline induced hepatocellular adenoma and carcinoma in female mice.

7.2.1.2 Dermal Carcinogenesis:

Mouse skin painting studies have been performed for over 50 years in the petroleum industry to identify potential hazard of skin cancer to workers and to establish safety procedures and guidelines for protective clothing. The standard skin painting study protocol involves applying the test material to the shaved backs of male mice (50 /group) at a concentration of 50µl twice weekly for approximately 2 years. The test material is usually applied undiluted or, if extremely viscous or irritating diluted in solvent (e.g. toluene). A positive control compound such as benzo(a)pyrene diluted in toluene may be included. Physical examinations for dermal irritation and tumors are performed weekly. In some studies body weights may be recorded weekly. All mice are examined at death or scheduled sacrifice and selected organs may be weighed. Application sites are fixed, stained and examined histopathologically. Tumors confirmed by histological examination are used in calculating tumor incidence. The average latency period, the average time to appearance of the first tumor in each animal affected, is calculated. The tumor data is compared statistically (e.g. Chi square test) with the data from the untreated and solvent controls. Table 7 summarizes the skin painting results for samples of Gasoline Blending Streams

Table 7. Mouse Skin Painting Results for Naphtha Streams and Gasoline

Stream	API ID	No. of mice with tumors	Latency (wks)	Comments	Results Reference
Gasoline, unleaded	81-24	2	123	Local skin toxicity, no systemic toxicity at 12 month. Toluene control 4 mice with tumors.	Not a carcinogen API, 1989a
Lt Alkylate naphtha	83-19	1 [0B; 1M]	103	Local skin toxicity, no systemic toxicity at 12 month.	Not a carcinogen API, 1989b
Sweetened naphtha	81-08	3 [2B; 1M]	113	Local skin toxicity No systemic toxicity at 12 months. Toluene control 4 mice with tumor. Not initiator or promoter	Not a carcinogen API, 1989a,c
Heavy Cat reformed naphtha	83-06	0	-0-	Local skin toxicity, no systemic toxicity at 12 month.	Not a carcinogen 1989b
Lt. Cat. cracked naphtha	81-03	7 [2B; 5M]	118	Local skin toxicity, no systemic toxicity at 12 month. Toluene control 4 mice with tumor.	Positive, weak dermal carcinogen API, 1989a
Heavy Cat. cracked naphtha	83-18	6 [1B; 5M]	72	Local skin toxicity, no systemic toxicity at 12 month.	Positive, weak dermal carcinogen API, 1989b

Heavy Thermally cracked naphtha	84-02	6 [3B; 3M]	88	Local skin toxicity, no systemic toxicity at 12 month.	Positive, weak dermal carcinogen API, 1989b

B = benign tumor; M = malignant tumor

Conclusions: Dermal carcinogenesis occurred primarily in gasoline blending streams derived from cracked stocks. All streams produced skin irritation at the site of application. The paraffinic light alkylate naphtha and the aromatic heavy catalytic reformed naphtha samples were not dermal carcinogens. Sweetened naphtha did not induce a significant incidence of skin tumors in the lifetime skin painting study (API, 1989a) and was demonstrated not to have initiating or promoting properties (API, 1989c). No systemic toxicity other than skin irritation was reported after 12 months of exposure for any of these materials.

7.3 Assessment Summary for Health Effects

A substantial body of data has been compiled on representative blending streams and on formulated gasoline. These naphthas demonstrate consistently low acute toxicity by oral, dermal and inhalation exposure, are only mildly irritating to the eye, are mild to moderate skin irritants and are not skin sensitizers. Results of repeat dose mammalian studies for naphtha streams have demonstrated fairly similar profiles of toxicity across the 4 chemical classes. When applied dermally, representatives of gasoline blending streams induced skin irritation with the only systemic effects related to skin damage and accompanying stress. In inhalation studies, exposure was to distillate fractions typical of the most likely human exposure, or to vapor generated directly from the liquid blending stream. Due to the restrictions imposed by explosive limits, distillate studies could be performed at much higher concentrations than vapor studies. In most studies, minimal toxic effects were observed with the exception of alpha 2-microglobulin mediated nephropathy, also identified as light hydrocarbon nephropathy in male rats, a species and sex specific syndrome not relevant to human health (US EPA, 1991). Other general systemic effects included increased liver weight, some decreases in body weight or small changes in clinical pathology parameters and a decrease in sperm/grams of epididymis in one olefinic sample, an effect not supported by other male parameters in that study or in other studies. Gasoline blending streams have a low inhalation repeat dose hazard potential. The inhalation NOAELs and LOAELs were similar between the different hydrocarbon classes of streams (PONA) and the formulated product, gasoline in rats. Since there were no appreciable differences between paraffinic, olefinic, naphthenic, and aromatic streams, a range of values derived from all of the repeated dose inhalation studies will be used to read across to all untested category members. These read-across values are:

LOAEL: 6572 mg/m^3 – 27,800mg/m^3 (1864 – 7885ppm[a])
NOAEL: 1507mg/m^3 – 10,153mg/m^3 (427 – 2880ppm[a])

[[a] - upper range of NOAEL based on 211(b) BGVC; Total hydrocarbon determined as parts-per-million (ppm) hexane equivalents.]

Gasoline blending streams are overall not genotoxic. Testing of PONA streams in mammalian cells gave generally negative results across chemical classes except for a few equivocal and one positive finding for samples with higher aromatic content. The read-across conclusions for all streams in this category are negative with and without metabolic activation with the exception

of streams with a known aromatic content greater than 60% that can be classified as negative/equivocal without metabolic activation and equivocal/positive with metabolic activation.

In vivo cytogenetic studies by the intraperitoneal or inhalation routes did not result in chromosomal damage or cell cycle toxicity. Equivocal results for sister chromatid exchanges *in vitro* and a positive result *in vivo* were seen with two separate olefinic samples, indicative of interaction with DNA but not definitive for genetic toxicity since no genetic material was unbalanced or lost. SCE can be considered a biomarker of exposure rather than a direct indicator of mutagenic effect. The read-across conclusion for untested streams in this category is negative for in vivo genetic toxicity

Reproductive or developmental toxicity was not observed by dermal exposure or by inhalation of distillate or vapor samples in any PONA class with the exception of a 40% olefinic vapor sample developmental study in which increased resorptions were reported at the highest dose. Increased resorptions were not seen in a similar olefinic naphtha sample containing 60% olefins in the vapor nor in other naphthas tested. Thus this study was excluded from determining a read-across range because these results appeared specific to this sample and not representative of refinery streams in general. The NOAEL values for developmental and reproductive effects reflect the maximum doses tested. Parental systemic LOAEL and NOAEL values over all developmental and reproductive studies reflect primarily decreases in body weights at maximum doses. The read-across ranges for untested streams in this category are:

Developmental NOAEL = 5970mg/m^3 to 27750mg/m^3,

Reproductive NOAEL = 13650 mg/m^3 to 27750 mg/m^3

Parental systemic toxicity LOAEL = 13650 mg/m^3 to 27750 mg/m^3:
NOAEL = 2275 mg/m^3 to 25000 mg/m^3

Results from toxicity studies in gasoline for repeat dose, genetic toxicity and reproductive/ developmental endpoints are consistent with results from tests on these refinery blending streams. The formulated gasoline study results confirm the category hypothesis that there are not significant differences in toxicity between the PONA streams, and separation of streams for hazard characterization is not necessary. Additionally, these results justify the strategy of using all studies to establish endpoint ranges to read across to untested category members.

Long term inhalation exposure to gasoline produced tumors in male rat kidneys, the result of alpha 2-microglobulin mediated nephropathy, a species and sex specific syndrome not relevant to human health (US EPA, 1991). In female mice there was an increase in hepatocellular adenomas and carcinomas.

Skin tumors were induced after 2 years dermal exposure primarily by naphtha streams derived from cracked stocks. No systemic toxicity was reported after 12 months exposure. Other gasoline blending streams and gasoline produced skin irritation but did not induce any or any significant incidence of skin tumors.

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